SILICON CHIP

FEBRUARY 2018
ISSN 1030-2662
02
PP255003/01272
$9.95* INC GST NZ$12.90 INC GST

The BEST DIY Projects!

$9.95 W8
SILICON CHIP
Cov
February 2
510
240116 7
GG 33956
Greensborough Plaza Ne
007-003-003

...from ANYWHERE!

...me & Farm Water Tank Level Meter

...with inbuilt Wi Fi™,
...inbuilt weather reporting
...and it's solar powered!

Avoid 4G phone interference:

6-Element VHF TV YAGI

Easy to build — High performance

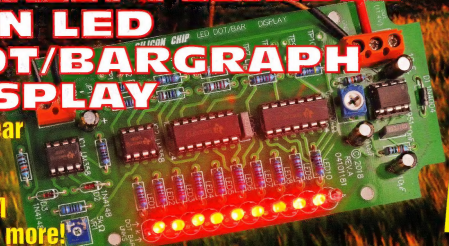
We review:

NAVMAN'S DRIVEDUO

Much more than a satnav
Much more than a dashcam!

REALLY FLEXIBLE TEN LED DOT/BARGRAPH DISPLAY

- Linear
- Log
- VU
- PPM
- And more!



FEATURE: Turning rubbish into electricity!

Jaycar Electronics
Better. More Technical

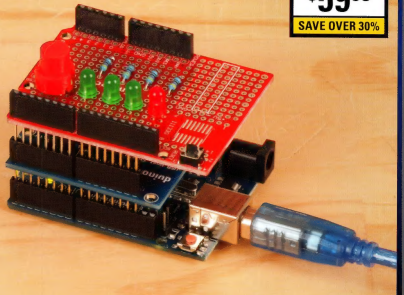
duinotech
PROJECT OF THE MONTH

Our very own specialists are developing fun and challenging Arduino®-compatible projects for you to build every month, with special prices exclusive to Nerd Perks Club Members.

BUILD YOUR OWN DUINOTECH UNO PROGRAMMER!

Use an Uno to program an Uno!
Using the USB Host shield, we can actually use an Uno to download a hex file to another Uno. Adding a nifty shield with one big red button and some status LEDs makes a complete standalone device. Handy if you have a few Unos to program or you just want to learn more about how the download process works.

NERD PERKS CLUB OFFER
BUNDLE DEAL
$59.95
SAVE OVER 30%



VALUED AT $89.05

SEE STEP-BY-STEP INSTRUCTIONS AT:
jaycar.com.au/uno-programmer

WHAT YOU NEED:

1 X UNO MAIN BOARD	XC-4410	$29.95
1 X USB HOST SHIELD	XC-4456	$39.95
1 X PROTOTYPING SHIELD	XC-4482	$15.95
1 X RED 5MM LED	ZD-0150	$0.30
3 X GREEN 5MM LED	ZD-0170	$0.30
1 X RED PUSHBUTTON	SP-0720	$1.45
1 X 470 OHM RESISTOR PK8	RR-0564	$0.55

SEE OTHER PROJECTS AT: www.jaycar.com.au/arduino

MORE ROOM FOR A BIGGER PROGRAM

DUINOTECH MEGA XC-4420
Our most powerful Arduino® compatible board. Boasting more IO pins, more memory, more PWM outputs, more analogue inputs and more serial ports.
- 256kb program memory
- ATMega2560 Microcontroller
- 108(W) x 53(L) x 15(H)mm

$49.95

ADD A STATUS DISPLAY

$29.95

OLED DISPLAY MODULE XC-4384
Monochrome graphics with wide viewing angle and I2C interface.
- SSD1306 Chipset
- 22(L) x 22(W) x 12(H)mm

ADD A SOUND ALERT

$9.95

RECORD AND PLAYBACK MODULE XC-4605
Includes a small built in amplifier capable of directly driving an 8 Ohm speaker. Ideal if you need to play back a specific sound.
- Records up to 10 seconds.

NERD PERKS CLUB MEMBERS RECEIVE:

20% OFF
SOLAR PANEL MOUNTING HARDWARE*

*Includes Solar Panel Mounting Bracket, ABS Solar Panel Mounts & ABS Solar Cable Entry Point.

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!
*Conditions apply. See website for T&Cs

REGISTER ONLINE TODAY BY VISITING:
www.jaycar.com.au/nerdperks

Contents

Vol.31, No.2; February 2018

SILICON CHIP

www.siliconchip.com.au

Features & Reviews

14 Turning your garbage into useful electricity

Most garbage still goes to landfill – but in many cities around the world, it's used as fuel for boilers to generate power. There are at least two firm proposals to do so here in Australia, if the NIMBYs don't scuttle the plans – by Ross Tester

30 We review: Navman's DriveDuo – Satnav AND Dashcam

After a less-than-stellar performance with our last Satnav, we were more than pleasantly surprised by the DriveDuo. It combines a state-of-the-art Satnav with a very high performance Dashcam – and does both very well – by Leo Simpson

44 El Cheapo Modules 13: sensing motion and moisture

Two very different modules this month: first is a motion sensor that uses microwaves instead of the normal infrared; second is a soil moisture measurement system for pot plants, gardens, etc – by Jim Rowe

Constructional Projects

20 A Water Tank Level Meter with WiFi and More!

Got a water tank? Want to know how much water is in it? This one not only tells you (anywhere on Earth, via WiFi) it can also log all the details for you. But wait, there's more: it also has inbuilt weather reporting – by Nicholas Vinen

36 6-Element VHF TV Yagi to kill UHF 4G interference

If you're still using a VHF/UHF antenna in metro areas, chances are you're also picking up a lot of unwanted 5ubbish from the now-vacated UHF TV bands. This VHF-only TV antenna is what you need! – by Leo Simpson

64 Highly versatile & accurate dot/bar 10-LED Bargraph

With the venerable LM391X series now getting difficult (if not impossible) to obtain we developed this 10-LED display module to take their place. It can display log, linear, VU or PPM signals in dot or bar form – by John Clarke

83 The Arduino Mega Box Music Player revisited

The Mega Box concept (Dec17/Jan18) has proved popular, but we thought it needed some refinement. So we added a music player, made provision for remote control and updated the software. Now it really sings! – by Bao Smith

Your Favourite Columns

57 Serviceman's Log

Smart TVs can be pretty dumb sometimes – by Dave Thompson

78 Circuit Notebook

(1) Vintage car logbook reminder with temperature and clock display
(2) PICAXE roulette wheel simulator using 7-segment displays
(3) Active probe uses switched capacitor charge pump
(4) OLED clock gets its time from the internet using NTP

87 Vintage Radio

A more detailed look at the 1919/20 Grebe Synchrophase – by Ian Batty

Everything Else!

2 Editorial Viewpoint
4 Mailbag – Your Feedback
94 Ask SILICON CHIP
100 SILICON CHIP Online Shop
103 Market Centre
104 Advertising Index
104 Notes and Errata

Thousands of cities around the world are generating power from rubbish – Page 14

Using low-cost modules, this water tank depth gauge relays its data via WiFi, along with current weather – Page 20

The Navman DriveDuo is more than a SatNav; it's more than a dashcam. It's both – in one high-performance package – Page 30

Old-style multi-band (VHF/UHF) TV antennas can be plagued by annoying 4G interference on UHF – if you're in a metro area (VHF only) build this Yagi Antenna – it simply won't receive UHF! – Page 36

The Grebe Synchrophase is so exceptional that it warrants a detailed analysis, with its performance rivalling some of the finest superheterodyne sets of the period – Page 87.

Find us on Facebook

www.facebook.com/siliconchipmagazine

SILICON CHIP
www.siliconchip.com.au

Publisher
Leo Simpson, B.Bus., FAICD

Editor
Nicholas Vinen

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Bao Smith, B.Sc

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Dave Thompson
David Maddison B.App.Sc. (Hons 1), PhD, Grad.Dip.Entr.Innov.
Geoff Graham
Associate Professor Graham Parslow
Ian Batty

Cartoonist
Brendan Akhurst

SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Subscription rates: $105.00 per year in Australia. For overseas rates, see our website or the subscriptions page in this issue.

Editorial office:
Unit 1 (up ramp), 234 Harbord Rd, Brookvale, NSW 2100.
Postal address: PO Box 139, Collaroy Beach, NSW 2097.
Phone (02) 9939 3295.
E-mail: silicon@siliconchip.com.au

Printing and Distribution:
bluestar
Derby Street, Silverwater, NSW 2148.

ISSN 1030-2662
Recommended & maximum price only.

Editorial Viewpoint

Yet another threat to surfing the net

Just as this issue was going to press, news broke about a number of related vulnerabilities in Intel and compatible CPUs. Known as "Spectre" and "Meltdown", they allow untrusted programs to read sensitive data.

These vulnerabilities exist in pretty much every desktop and laptop PC in use today and some tablets and phones may also be affected. And there's a problem with the timing of this news because companies like Microsoft had hoped to release fixes before these problems became public knowledge. But now the cat is out of the bag.

While it should be possible to change operating systems to prevent malware from exploiting these flaws, those changes are likely to degrade overall system performance. Some estimates are that this could slow down your computer as much as 30% but recent bulletins from companies like Apple suggest that this won't be the case.

So what can you do? Well, if you're paranoid or dealing with top-secret information, you could stop using your computer until updates are available. However, at any given time, it's virtually guaranteed that someone, somewhere knows about a flaw in your operating system (whether it's Windows, Linux, Mac OS or something else) that could be exploited to access your private data.

These do eventually come to light and eventually they are patched. But there may be a window of days, months or even years during which malicious parties can take advantage of them to create viruses, worms, trojans and other assorted nasties.

Unless you become a hermit and live in a cave in the mountains, I'm not sure that you can ever be be completely safe from such flaws. You could keep a separate computer to use only for sensitive tasks (banking and so on), and keep it unplugged from the internet most of the time. That may not make you 100% safe but it would probably help. But you would still need to keep the software on that machine up-to-date.

So why didn't anybody discover Spectre or Meltdown before? Apparently these problems have existed in Intel CPUs as early as 1995 and possibly even earlier but they are quite subtle flaws and difficult to exploit.

I do not think it's very likely that we will see actual malware taking advantage of these, especially now that operating systems are being desperately patched. But I could be wrong.

Explaining the actual mechanism behind these flaws is difficult for all but the most advanced programmers to understand. In brief, they take advantage of the fact that you can get the processor to execute instructions which occur after accessing restricted memory, even though that access will trigger a fault interrupt. This is due to the "speculative execution" mechanism built into modern CPUs in order to speed them up.

While the CPU correctly discards the results of these invalid instructions, it still has to spend time executing them and by arranging for them to have a certain delay, then measuring that delay, it is possible to infer the contents of memory that a process does not actually have permission to access. That memory could belong to any process, including the kernel, and could contain sensitive data such as passwords.

Researchers have created software which takes advantage of this to read normally inaccessible memory. However, as I said above, I still think (or is that hope?) it's too difficult to use in actual malware. Time will tell if I am right.

More than anything else, these revelations indicate just how easy it is for a potentially serious security flaw to escape notice for many years. For most people, the best they can do it make sure that their computer always has the latest updates – and don't ever click on attachments in emails from people that you don't know.

Nicholas Vinen

The World's Largest Selection of Electronic Components Available for Immediate Shipment™
A World of Solutions
FREE SHIPPING ON QUALIFIED ORDERS*
AUSTRALIA
DIGIKEY.COM.AU
1800 285 719
NEW ZEALAND
DIGIKEY.CO.NZ
800 449 837
Digi-Key® ELECTRONICS
6.8 MILLION+ PRODUCTS ONLINE | 650+ INDUSTRY-LEADING SUPPLIERS | 100% AUTHORIZED DISTRIBUTOR
*Australia: A shipping charge of $24.00 AUD will be billed on all orders of less than $60.00 AUD. A shipping charge of $20.00 USD will be billed on all orders of less than $50.00 USD. All orders are shipped via UPS, Federal Express, or DHL for delivery within 3-4 days (dependent on final destination). No handling fees. All prices are in Australian dollar or United States dollar. New Zealand: A shipping charge of $26.00 (NZD) will be billed on all orders of less than $66.00 (NZD). A shipping charge of $20.00 USD will be billed on all orders of less than $50.00 USD. All orders are shipped via UPS for delivery within 3-4 days (dependent on final destination). All prices are in New Zealand dollar or United States dollar. Digi-Key is an authorized distributor for all supplier partners. New product added daily. Digi-Key and Digi-Key Electronics are registered trademarks of Digi-Key Electronics in the U.S. and other countries. © 2018 Digi-Key Electronics, 701 Brooks Ave. South, Thief River Falls, MN 56701, USA
ecia MEMBER
ecsn
CEDS

MAILBAG – your Feedback

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP", "Circuit Notebook" and "Serviceman".

Rapid changes in electronics leave newcomers behind

After working in the electronics industry for more than 25 years I have seen massive changes and in people's attitudes as to what an electronics whiz actually is.

I have been lucky to progress as a technician, from working on the bench repairing Apple computers to component level (yes here in Australia with Triad/AWA-TES) to now installing and servicing underground voice communication systems in mines.

Some of our older guys may regard this as simply being a "board jockey". I now spend very little time now on the bench with a multimeter and scope, to repair the odd bit that no one else can or dare do, as repairs aren't what they used to be; that's for sure!

After looking up Google and reading articles in other magazines, it seems that today's "electronics whiz" thinks that they can get a Raspberry Pi, whack a few modules together, then just tap on the keyboard to code up some XOR and AND algorithms (I/Os to keep things simple for them) and make a useless toy car move across the floor.

Yet people may see this as an amazing achievement of an electronic whiz!

This is where I have concerns for the future of actual electronics. These keyboard tappers that make things move and flash don't understand how electronics work and the small number of real electronics technicians are shrinking, as these "electronics whiz" kids don't actually learn and understand how to fix a bench power supply, apart from replacing a blown fuse.

I understand people must start somewhere and we are in a disposable world today. We still need to keep things in perspective though, to try to keep this hobby and/or trade alive.

I would like to thank my father for my development in the electronics hobby and working career. That has developed further with SILICON CHIP over the last 30 years and I'm so glad that you have evolved for the true hobbyist, technicians and keyboard tappers alike, with greater depth and understanding.

You keep explaining why and how analog and digital circuits work with real applications; much better than Googling through 1000s of rubbish pages just to find one good application.

To sum it all up, thank you SILICON CHIP, for keeping it real for all of the real electronics whizzes out there.

Mats Nilsson,
Blaxland, NSW.

Comment: Thanks for your enthusiastic endorsement, Mats. It is much appreciated.

You are right in that many of today's hobbyists often do not have the detailed insights into electronic components that older readers will have obtained from their fathers or local technicians or from dabbling with old radios and other electronic bits and pieces. It is also true that very few schools today give any insight into the wonderful world of electronics.

However, electronics has always been subject to rapid changes and we regard the apparent preoccupation of today's younger readers, with Arduino, Raspberry Pi and other single-board computers such as our own Micromite/Maximite designs, as an opportunity.

So SILICON CHIP can and does provide detailed information on the very cheap modules which are now available and which can be combined with Arduinos etc in really useful applications rather than simply flashing a few LEDs, sounding a buzzer or operating a relay.

And in providing this information, it gives readers the potential to become much more knowledgeable in their electronics hobby. After all, these very cheap modules are really just a step up from integrated circuits, aren't they?

The Publisher's Letter in the October 2016 issue covered this theme.

Superhet patent situation is complex

My letter is regarding Peter Hadgraft's comment "Superheterodyne principle was developed by multiple people" (Mailbag, January 2018 issue, page 11).

In Armstrong's paper "A NEW SYSTEM OF SHORT WAVE AMPLIFICATION" (presented before the Institute of Radio Engineers, New York, December 3, 1919), Armstrong specifically acknowledges the work of Levy and others:

"The new practice of this method involves the use of many known inventions, but in connection with the production of a superaudible frequency by heterodyning I wish to make due acknowledgment to the work of Meissner, Round, and Levy, which is now of record.

The application of the principle to the reception of short waves is, I believe, new and it is for this reason that this paper is presented."

"Heterodyne" reception, that is, generating an audible signal from an inaudible CW Morse transmission by means of using a separately generated carrier to produce a beat tone, was already a well-established technique. For all their inherent vices, spark transmitters had the virtue of producing a clear and pleasant "note" in the receiver earphones.

Later continuous-carrier devices such as Alexanderson alternators and Poulsen arcs gave far more bang for the buck (efficiency-wise) but Morse transmissions from those, consisting of bursts of unmodulated carrier, could only be heard as feeble clicks.

Various techniques were devised to overcome this problem. Some Alexanderson alternators were constructed with two generators on the same shaft producing carrier frequencies about 3kHz apart which produced an audible "heterodyne" in the receiver. Others attempted to use miniature Poulsen arc generators in the receiving station to generate the heterodyne.

Later, when practical valve receivers became available, the familiar Beat

From 50 MHz to 6 GHz:
Powerful oscilloscopes from the T&M expert.

HD 16 bit

Multi Domain

Fast operation, easy to use, precise measurements.

R&S®RTO2000: Turn your signals into success. (Bandwidths: 600 MHz to 6 GHz)
R&S®RTE: Easy. Powerful. (Bandwidths: 200 MHz to 2 GHz)
R&S®RTA4000: Power of ten. (Bandwidths: 200 MHz to 1 GHz)
R&S®RTM3000: Power of ten. (Bandwidths: 100 MHz to 1 GHz)
R&S®RTB2000: Power of ten. (Bandwidths: 70 MHz to 300 MHz)
R&S®RTC1000: Great Value. (Bandwidths: 50 MHz to 300 MHz)
R&S®Scope Rider: 2 minutes to be sure. (Bandwidths: 60 MHz to 500 MHz)

All Rohde & Schwarz oscilloscopes incorporate time domain, logic, protocol and frequency analysis in a single device.

Take the dive at www.scope-of-the-art.com/ad/all
sales.australia@rohde-schwarz.com

ROHDE&SCHWARZ

Frequency Oscillator (BFO) made these techniques obsolete.

Operators already knew that if the BFO frequency was moved too far from the carrier frequency, the heterodyne became "supersonic" and no longer audible.

However, it was Armstrong who realised that if a standard low-frequency TRF receiver was connected in place of the receiver headphones, it should be possible to achieve useful amplification of so-called "short-wave" signals (meaning anything above about 200kHz).

You have to remember that a lot of what we now see as major technological breakthroughs were not really appreciated at the time they were patented. It's only when a technology becomes profitable years later that competitors start sniffing around for ways to invalidate potentially inconvenient patents.

Also, many dubious decisions about patent validity have been made by non-technical judiciary in ordinary courtrooms. Patents eventually expire and are forgotten but the imaginative stories spun in courtrooms seem to have no such expiry date!

In particular, at the time of Armstrong's invention, "Short Waves" were considered practically useless for "serious" communication work; the broadcasting blitzkrieg to come lay five years in the future.

www.americanradiohistory.com has a huge collection of early radio magazines, some dating back to the early 20th century, all available for free download.

In particular, there's an almost complete collection of "Wireless World" dating back to 1912 but none of the major technological advances that took place between then and the 1920s seems to rate a mention!

Keith Walters,
Riverstone, NSW.

Don't power Graphic Equaliser from same transformer as amplifier

I have completed the 10-Octave Stereo Graphic Equaliser you published in the June and July 2017 issues (siliconchip.com.au/Series/313). I put it in an enclosure together with the LED VU Meter from the June and July 2016 issues (siliconchip.com.au/Series/301).

The input of the Equaliser is coming from my AV amp pre-out. The output of the equaliser is feeding my Ultra-LD Mk.4 Amplifier (July-October 2015; siliconchip.com.au/Series/289) which drives my KEF speakers.

The equaliser power supply comes directly from the 15-0-15 output of the toroidal transformer in the amp; the same winding that feeds the power supply module.

The connection between the two enclosures uses three non-shielded wires. The reason I have done it this way is so that the Equaliser and VU Meter are switched on and off with the amplifier and I do not need a separate plugpack or DC supply.

When everything is connected per described, I noticed some kind of continuous noise in the speakers with no input signal (and volume at the minimum). If I disconnect the VU Meter from the output of the 7815 regulator on the Equaliser board, I notice a significant reduction of the noise in the speaker. However, I still hear a low-frequency noise.

I noticed that regardless of which of the three inputs are selected on the Ultra-LD Mk.4 amplifier, the noise remains the same. This makes me think it's some kind of ground loop or bad connection. If I play some music it becomes inaudible but I want to get rid of it totally.

I tried powering the Equaliser from the 20V DC output of the Ultra-LD Mk.4 power supply but it made no difference to the noise. If I use a separate AC plugpack to power the Equaliser, it almost totally eliminates the noise (I can still hear it if I press my ear up to the speaker but it's more than acceptable).

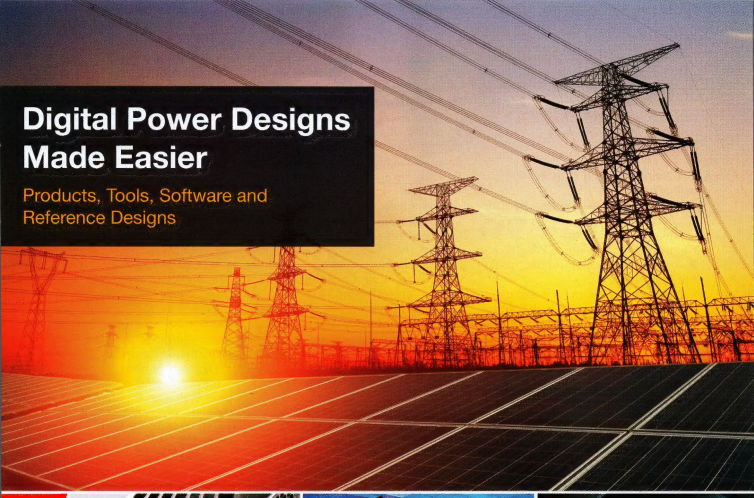
I also tried unplugging the two RCA cables from the pre-out of my AV receiver that feeds the Ultra-LD Amplifier and the remaining noise completely disappears! In that case, no matter what the volume is set at, my speakers are absolutely dead silent with the Equaliser on. It works perfectly when I feed some music via the CLASSiC DAC.

So we can conclude that the Equaliser should be powered from a separate supply, not from the same transformer that is powering the amplifier.

However, I clearly have still some kind of ground loop involving my AV receiver. There is an earth connection at the back of its enclosure which I do not use. Perhaps I need to connect it to something.

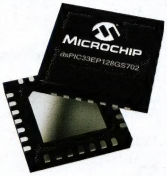
Digital Power Designs Made Easier

Products, Tools, Software and Reference Designs



Microchip's digital power design suite includes the Digital Compensation Design Tool (DCDT), MPLAB® Code Configurator (MCC), Microchip compensator libraries and design examples.

These four components of the digital power design suite provide the tools and required guidance for developing complete digital power designs. Once the initial simulation model of your design is ready, the DCDT can be used to analyze the design and the feedback transfer function, and to generate compensator coefficients. Device initialization code can be generated with the help of MCC; and the final firmware can be created with some help from the code examples and the code generated from MCC and the DCDT.



Key Features

- Digital Compensation Design Tool to analyze your design
- Libraries and design examples to jump start your development
- Feature-rich dsPIC33EP "GS" family of DSCs

Contact Information
Microchip Technology Australia
Email: aust_nz.inquiry@microchip.com
Phone: +61 (2) 9868-6733

microchip DIRECT
www.microchipdirect.com

MICROCHIP

www.microchip.com/DDSMCU16

The Microchip name and logo, the Microchip logo and MPLAB are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries. All other trademarks are the property of their registered owners. © 2018 Microchip Technology Inc. All rights reserved.

The AV receiver power supply plug only has two pins (ie, no earth). I will try connecting the receiver earth to the amplifier chassis. But for now, the problem is solved.

Olivier Aubertin,
Singapore.

Monitoring electricity consumption using Beaglebone

Regarding the letter on page 98 of the December 2017 issue, about an energy meter to monitor the whole house; I am doing this using a Beaglebone Black as it has analog inputs, unlike the Raspberry Pi.

I am running Linux on it and using a Python script to monitor the output of a 50A to 5V DC split core current transducer. A plot showing the usage is reproduced below.

In this, you can see the power drawn by my kettle (tall spikes), spa pump (between 12:00 and 14:30), oven (17:45 to 18:45), plus two fridges (which look like oscillations in the baseline).

From my perspective, the disturbing component is that the current never falls below 1A. That's 5.8kWh each day, nominally a third of the day's usage, doing what? My guess is that it's my laptops, internet modem, chargers, central heating on standby, security system and other appliances drawing phantom power.

I do not monitor the phase of the current with respect to the supply voltage so I apply a small fudge factor so that the integral of the graph approximates the electricity meter readings.

Andrew Goss,
Northcote, Vic.

The Ultra-LD Mk.4 amplifier as a school project

My name is Christopher Morton and I am the Electronics Technician at Scotch College in Melbourne, Victoria. Part of my job role at Scotch College is to find and develop items for the school curriculum specifically relating to electronics.

We currently purchase and make a number of kits (which incorporate through-hole components) that have been showcased in your magazine through various suppliers (Jaycar & Altronics).

As technology improves, so does the manufacturing methods involved in these processes, to which end we are interested in bringing some of these "new" technologies into the classroom, one of these being the use and repair of SMDs (Surface Mount Devices).

As more and more devices in this world rely heavily upon this method of manufacturing, we feel that moving the next generation of thinkers and doers in this direction is a good first step in keeping up with emerging technologies.

We propose to have several hundred boards made for your Ultra-LD Mk.4 Amplifier, featured in the September 2015 issue of your magazine, along with solder paste stencils, so that our students can build them as part of their coursework next year.

We are also interested in a smaller project (15 to 18 components 1206 in size) for some of the junior year groups (Years 7 & 8) and would appreciate any recommendations. We currently build a through-hole flip-flop flasher circuit and would be interested in developing this into SMD version.

Christopher Morton,
Scotch College,
Hawthorn, Vic.

Response: we are happy to see that you want to use one of our projects at your school. Thanks for supporting our magazine and the kit set suppliers. Please keep in mind that some of the transistors for the Ultra-LD Mk.4 project are now difficult to obtain. We have found possible alternatives but we have not tested them in the design.

These are the Rohm IMT4T108 (PNP; similar to HN3A51F) and IMX8T108 (NPN; similar to HN3C51F). They are still available although they are indicated as "not for new designs".

We have some HN3A51F and HN3C51F in our Online Shop but our stock is not sufficient for your needs, so we suggest you build an Ultra-LD Mk.4 amplifier using the Rohm transistors and verify it works before proceeding.

*We have produced a few projects which would suit your year 7 and 8 students. For example, the USB chargers in the July 2015 and September 2015 issues (**siliconchip.com.au/Series/292**), the 2 x 5W mini amplifier from the November 2014 issue (**siliconchip.com.au/Article/8064**) and the Digital Sound Effects Module from the September 2012 issue (**siliconchip.com.au/Article/537**).*

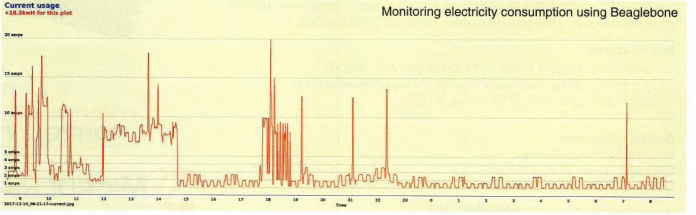
*The MiniSwitcher regulator from February 2012 also includes a number of large SMDs (**siliconchip.com.au/Article/774**) as well as some through-hole components.*

We will consider producing more projects in future which provide a gentle introduction to SMDs. They should be good for beginners who may not be used to working with surface mount parts.

Incidentally, if you want large quantities of our PCB, we offer significant discounts for bulk orders on the SILICON CHIP Online Store.

Electrolytic corrosion should not occur in hot water heaters

Regarding the letter titled "Preventing corrosion in solar-boosted hot water systems" in the Mailbag section of the December 2017 issue (page 5), all electric storage hot water tanks have



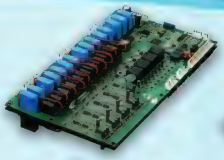
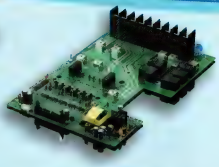
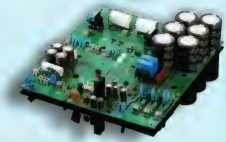
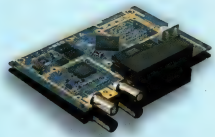
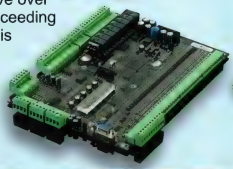
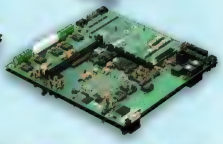
LEACH

EMS SINCE 1999

Your most reliable electronic contract manufacturing partner

Engineering expertise in complex PCB assembly for industrial control, medical/health care, Telecom, Energy, traffic signs etc.

LEACH offer:
*OEM & ODM service
*Components global procurement
*Prototype and NPI
*PCB Assembly (SMT/DIP)
*AOI & ICT functional testing
*Cable assembly and Box-build
*Global Logistics

Covering an area of 2000m^2, we have over 100 employees and annual sales exceeding $US10,000,000, over 80% of which is exported worldwide.
The well-equipped facilities and excellent quality control throughout all stages of production enables LEACH to guarantee total customer satisfaction.

SMT LINES

REFLOW OVEN

LEACH (HK) CO. / LEACH (SZ) CO. LTD

Address: Floor 2, Block 2, Wandi Industrial Park,
Xikeng Laocun, Guanlan, Longhua, Shenzhen, China 518110
TEL: +86 755 89580259 FAX: +86 755 89504192
E-MAIL: info@leach-pcba.com

Are your copies of SILICON CHIP getting damaged or dog-eared just lying around in a cupboard or on a shelf? Can you quickly find a particular issue that you need to refer to?

Keep your copies safe, secure and always available with these handy binders

These binders will protect your copies of SILICON CHIP. They feature heavy-board covers, hold 12 issues & will look great on your bookshelf.

- 80mm internal width
- SILICON CHIP logo printed in gold-coloured lettering on spine & cover

Silicon Chip Publications
PO Box 139
Collaroy Beach 2097

Order online from www.siliconchip.com.au/Shop/4 or call (02) 9939 3295 and quote your credit card number. *See website for overseas prices.

their heating elements housed within a sealed, non-corrodible metallic sheath.

Therefore it does not matter what the nature of the electrical supply is, provided the appropriate AC or DC element is used.

I do remember porcelain electric hot water jugs having an exposed wire-type element. However, I do not recall seeing any corrosion of the two brass conductors supporting the submerged element.

Notwithstanding the above, under certain conditions for AC (and to a greater extent, DC), electricity will cause accelerated corrosion. For example, steel in a corrosive environment such as an uncoated steel earthing electrode in moist soil will naturally corrode over time.

However, if this electrode is connected to an earthing system and is passing AC current, it will experience accelerated corrosion.

The rate of this corrosion would be only of the order of 2% of the corrosion produced by the equivalent direct current (DC).

Dick Webster,
Port Melbourne, Vic.

Using Raspberry Pi to monitor house electricity consumption

In the Ask SILICON CHIP section of the December 2017 issue, there was a question regarding "Energy Meter required to monitor whole house".

I am running software called "emoncms" (http://emoncms.org) on a Raspberry Pi with emonTx V3 (https://shop.openenergymonitor.com/sensor-nodes/) electricity monitor which uses clip-on current sensors, installed in the meter box.

I am on a rural property which has reasonably frequent blackouts, so I monitor the network feed (to monitor our total draw), the feed to the house (to monitor the draw from the house), the feed to the shed (to monitor the draw from the shed) and the feed from the standby generator (to monitor generator usage when we have a blackout).

I have also reserved a current sensor to monitor solar panels (when I get those installed).

The emonTx measures current every eight seconds and sends the data wirelessly to the emoncms software running on the Raspberry Pi.

There is heaps of information available, the web interface works well and there is even an app for your phone. Lots of documentation is available on the website and in the general community. I'm a bit of a fan of the Raspberry Pi and love this practical usage of it.

I have attached a screenshot of the MyElectric web app that shows current and historical usage (in watts; there is also a $/hour option). What more could you need? There are also apps for MySolar, MyHeatpump and MySolar&Wind.

It's definitely worth a look if you want to measure and monitor your power usage.

You can see an example screengrab of the program running below.

Al Lockyer,
Kangaroo Valley, NSW.

Going off-grid not economic at the moment

Dick Smith, in his email published in Mailbag in the January 2018 issue (on page 4), posed two questions in his first sentence: Is it worth having solar and batteries? Is it worth going off-grid (assuming the grid is easily accessible)?

Where the grid is available, for most people it is uneconomic to go off-grid at any typical level of domestic consumption, be that 2kWh per day or 20kWh. All that is saved is the standing charge, say $1/day. This has to pay for extra batteries to store the energy for when there is inadequate sunlight, and for a suitably sized inverter to meet maximum demand.

Assuming 2kWh/day (ie, minimal energy use) and five days of storage, a 10kWh deep discharge battery is required. Currently, this will cost at least $3650 with a possible lifetime of 10 years – ie, $1/day. Thus there are no savings and this does not take into account that the $3650 could otherwise be invested.

For more realistic domestic situations, the battery cost goes up but the savings don't. The equation changes if there is a backup generator but it may not improve the economics.

A generator can reduce the amount of storage needed for those overcast days but a smaller battery capacity requires increased daily depth of discharge which will reduce the battery life. Also, there will be fuel costs and mechanical wear of the generator.

That said, any off-grid system that doesn't include a generator is running a risk. My grid-connected system was struck by lightning and had to be replaced completely. This would be a minor inconvenience for a grid-connected house but a big problem with an off-grid situation.

There is plenty of information about the economics of installing solar panels and batteries for domestic use so I don't think it is necessary to discuss it here.

A problem exists that some of the cost of the grid is built into electricity tariffs. Power stations are generating less electricity than previously, so the grid is costing more per kWh generated and this is passed to the customer.

Customers then have the incentive to generate more of their own power, leading to a feedback loop with grid usage heading downward and cost of electricity per unit going up.

If the trend continues, a point will be reached where it is economic to go off-grid. Those that can will, and the cost of electricity to those who can't will sky-rocket. That would be catastrophic.

A possible solution is the one used for water and sewerage. If it is available, you are charged for it regardless of whether you use it or not.

This should increase the standing charge and reduce the cost of electricity per kWh and may change the economics of domestic generation and storage. Economics could then favour the electricity generators investing in solar and batteries with huge economies of scale compared to domestic systems.

A possible future base load battery technology is the liquid metal battery. It operates at temperatures unsuitable for a domestic battery but has very desirable characteristics otherwise. Because the components are liquid, there is no deterioration with repeated charge/discharge cycles and the batteries should have an indefinite lifetime.

The components are cheap, the basic technology is simple and it should scale well. Unfortunately, due to patents, only one company is developing these and they don't seem to be making much progress. Hopefully, this is a temporary roadblock and MWh-scale batteries are coming.

I am in the throes of building an off-grid system for a bush block. It can be done relatively cheaply if one looks for bargains. I purchased 1kW of second-hand 24V solar panels for a little over $200.

These charge 9.6kWh of flooded Nicad batteries that were part of a backup system 15 years ago and purchased for a few hundred dollars. They had little use and work well, although I haven't tested their capacity.

There is no charge control at the moment, the panels are manually disconnected when charged. With flooded Nicad, some overcharging is not a problem and just requires the addition of distilled water. Before buying the 24V panels, I was using several small 12V panels and a 12V 1kW

OCEAN CONTROLS

Helping to put you in Control

LogBox Connect BLE
is abluetooth data logger with 3 universal analogue inputs and a digital I/O. Thermocouples, RTD's, 4-20mA, voltage and pulse output devices can be logged. A smartphone or PC can be used to configure and view logged data
SKU: NOD-010
Price: $449.95 ea + GST

UniPi Neuron M103 PLC
Based on the popular Raspberry Pi 3 model B the M103 is a universal cntrol unit with 12 DI, 12 DO, 1 AI, 1 AO and a 1 wire interface.
SKU: UPC-005
Price: $424.95 ea + GST

UniPi 1.1 Lite
Industrial grade I/O expansion board for Raspberry Pi 3 B board. Together they form a programmable control unit for universal use in automation, regulation, and monitoring systems.
SKU: RKS-113
Price: $134.95 ea + GST

Motor Driver for Raspberry Pi
Control two high-power DC motors with a Raspberry Pi. Its twin discrete MOSFET H-bridges support a wide 6.5 V to 30 V operating range and are efficient enough to deliver a continuous 22 A without a heat sink.
SKU: POL-3574
Price: $99.95 ea + GST

Soil Moisture and Temp Sensor
RK520-01 Combined Soil Moisture & Temperature Sensor and provides 4-20mA out.
SKU: RKS-055
Price: $249.95 ea + GST

LED Programmable Power Supply
Mean Well DRA60-12 can be used in LED driving applications. Output current is adjusted by a 10 vdc, potentiometer or PWM sensor.
SKU: PSM-1640
Price: $45.00 ea + GST

Thermocouple Multiplexer Shield
This shield allows you to connect 8k thermocouples to your Arduino.
SKU: KTA-259K
Price: $49.95 ea + GST

For Wholesale prices
Contact Ocean Controls
Ph: (03) 9782 5883
oceancontrols.com.au

Latronics inverter made in Australia. I am upgrading to a 24V 3kW inverter.

It took me a while to decide whether to buy a cheaper inverter or one with a good pedigree. I decided to buy another Latronics inverter despite the cost, based on the performance of the 1kW unit.

Most inverters I've looked at use a switchmode power supply to generate a high DC voltage, then use PWM and inductive filters to generate the AC output.

The Latronics inverter switches the battery voltage directly, feeding a transformer that generates the AC. This is a simpler method and appears to be more robust. It incorporates its own circuit breaker so an external one is not required, it will withstand 100% overload for short periods and is unaffected by power factor.

Latronics quote an expected lifetime of over 20 years and also provide a repair service should it fail. The backup is a 3500W inverter generator that cost $400 new and has done good work powering the tools to build the infrastructure for the solar system. Hopefully, in a few months, I'll be enjoying a cold beer straight from the fridge.

Alan Cashin,
Islington, NSW.

Comments on September issue

Thank you for another interesting issue of SILICON CHIP. I noticed that the Publisher's Letter is gone and replaced with the Editorial Viewpoint from Nicholas. I assume that this is a permanent change.

I believe that the view of Nicholas Vinen in the Editorial Viewpoint is rather conservative, to say the least. Without a massive increase in electricity production and/or a major reduction in domestic and industrial electricity consumption, there will be trouble.

I can understand the problems with pollution but that is generally a problem in major cities. I would have thought that the obvious solution would be to ban most internal combustion engines from the cities and require pedal power, electric vehicles, and public transport.

I am always puzzled by how "intelligent" people come to stupid decisions. Perhaps I am stupid in assuming that they are intelligent.

Thank you again for another nice general interest article on Cassini, by Ross Tester. It was interesting and it reminded me of the extreme effort that goes into designing such a machine and its operation. I always wonder if even technical people have any idea of the complexity. To quote a saying from an ex-POW camp prisoner, "If you haven't supped from the same cup, you cannot know the taste of it."

The article prompted me to have another look at the control of Cassini. In the process, I stumbled across a book by Nils Nilsson titled "The Quest For Artificial Intelligence" (2010) which is published as both a physical book and a free PDF. The link to the PDF is: http://ai.stanford.edu/~nilsson/QAI/qai.pdf

It is a fascinating book but be aware that there is some heavy mathematics in parts. Even so, Nils Nilsson does try to make it readable for most people. The most noticeable thing in the book is the number of ideas, techniques, and theories that were discovered before computers became readily available.

Not wishing to diminish the value of those discoveries, it must be stated that they were of little use generally until electronics made modern computers possible. Currently, there is an emphasis on the ability to write software. It has been forgotten that electronics is as important if not more so.

I was surprised to see a letter I wrote late last year published in the August issue (in Mailbag, on page 10-11). I thought that it had been discarded. I still dislike the idea of the "Internet of Things". But I must admit there are a few of things around the house that I wouldn't mind being able to check remotely and I do not mean away from my home.

If I am not in my laundry, I can only guess the state of the washing machine and the same applies to the microwave cooker when I am not in the kitchen. And occasionally I forget to close and lock the side door of my garage. It would be nice to be able to check it when I am in bed in winter without having to get up and look. In fact, it would be nice to have several doors and windows fitted with the appropriate sensors.

One problem with many appliances is that they have no status port. It may be possible to hook into their internal circuitry but there is the obvious danger of mains voltages being present.

The alternative is to mount external sensors that either detect the state of indicator LEDs or can identify the beeps that indicate cycle end and faults. That is what I did some years ago when I was working at the university.

I had bought some measuring equipment which I wanted to integrate into an automatic scanning system. I could easily trigger the start of a measurement but there was no signal available to indicate completion.

But then I noticed that completion was indicated by the activation of a small square on the screen of the computer that controlled the measuring equipment. So, I mounted a phototransistor in front of the square and was able to detect the measurement completion and start a new cycle.

Considering, the awkwardness of mounting a phototransistor, I think that the easiest solution would be to detect beeps. Using an LM567 tone decoder and setting it to the frequency of the beeps, detection and decoding would be simple operations. All I have to do is get motivated and do it.

George Ramsay,
Holland Park. Qld.

Response: thanks for your feedback. As you can see in the November issue, Leo will still be writing the occasional Publisher's Letter. We sometimes have to hold on to letters for a couple of months if we don't have space to fit them in the magazine. We try to avoid delaying them for many months, especially if they are topical.

Maximum theoretical efficiency for Class-A amplifier disputed

In the September 2017 issue on page 103, Ian Batty made a claim for "Class A's theoretical maximum of 50% efficiency".

If you want maximum undistorted output, sine or square wave, the DC quiescent point of the output must be $0.5V_{CC}$. Assuming 50% duty cycle for the square wave, and that the output can swing rail-to-rail, without a great deal of maths, the maximum power output can be shown to be $V_{CC}^2 \div (8 \times R_{load})$.

If you want maximum power transfer (Jacobi theorem),

the output impedance of the amplifier must equal R_{load}. Then, ignoring currents flowing in the base and the base biasing chain, input power = $V_{CC}^2 \div (2 \times R_{load})$. So, maximum efficiency = 2 ÷ 8 = 25%. If you design the transistor base bias resistor string to carry 10% of the collector current, then maximum efficiency falls to ~23%.

In the early days of germanium transistor amplifier design, for distortion and power supply regulation reasons, achieving rail-to-rail output voltage swing was considered impossible. Fritz Langford-Smith makes a similar statement about Class A valve amplifier design.

So, the 13% averaged efficiency Ian Batty found is not all that bad, although had he taken the current flow in the base bias string into account (5% of collector current), he would have found efficiency = 12%, ie, a little lower. Still, a commercial set achieving around 50% of theoretical maximum was pretty good in those days.

If you worship the Jacobi maximum power transfer notion, regulation is 50%. If you want better regulation, then the amplifier's output impedance must be much lower, resulting in higher collector, base and base bias string currents and hence, even lower efficiency.

Classes B and AB achieve higher efficiency because there is almost zero quiescent collector current; and in these classes, lower output impedance does not result in raised base or biasing string currents.

The way electricity distribution authorities achieve low regulation is via very low generator impedance compared with the load impedance. However, what is the maximum power distribution efficiency?

I find this claim for 50% efficiency of Class A amplifiers proliferates all over the internet and was repeated in one of Fred Swainston's books, with absolutely no support whatever. I think it's a furphy.

Brian Clarke,
BE, PhD, AOCP, BOCP, CPEng, Fellow IEAust,
via email.

Comment: we don't agree with this analysis for a number of reasons. Firstly, maximum power transfer theory is not applicable in the case of an audio amplifier.

In fact, it isn't applicable in any real-world situation that we know of. The reason is that if your source impedance equals your load impedance, by definition 50% of your power is dissipated in your source and that's an unacceptable inefficiency in virtually any real-world situation.

For this reason and to provide a reasonable damping factor, if you look at virtually any audio (or RF) amplifier, you will find the source impedance is very much lower than the load impedance.

*Our 20W Class-A amplifier module design, published in the May-September 2007 issues (**siliconchip.com.au/Series/58**), will deliver a low distortion sinewave of up to 25W into an 8Ω load with a quiescent power of just under 50W (1.12A from a ±22V supply).*

That's pretty close to the 50% theoretical efficiency that Ian Batty mentioned; clearly, the limit is not 25% or else our amplifier would not work.

Yes, our design is significantly more complex than the audio amplification section of the Philips MT4 Swingalong. But simulations of that circuit show that under the right conditions and with modern components, the exact circuit configuration Philips used is capable of efficiency in excess of 25%. SC

ICOM

IC-7610

Superior Receiver Performance and High-Purity Transmitter

Innovative RF Direct Sampling System

DIGI-SEL for Main and Sub Brands

Astonishing 110 dB RMDR

High Quality Speaker Sound

Customized VCXO is Used for the Master Clock

Digital-Up-Conversion (DUC) for Clean TX

Independent Dual Receiver

Built-in Automatic Antena Tuner

To find out more information about Icom's product range please email sales@icom.net.au

www.icom.net.au

MAKING POWER FROM RUBBISH

What do you do with a city's garbage and refuse? You send it off to landfill, of course. Well, until now that has been what most cities have done. But landfills fill up – and these days, can be politically incorrect. But (and it's a big but!) that could all be about to change, with many cities using garbage as fuel for electricity generation.

The photo above shows the Isséane refuse station in the heart of Paris, France, just 5km from the Eiffel Tower. You can see only about 21m of the building's height – the remaining 31m are underground.

In some ways, it's not too dissimilar to those waste transfer stations you'd find in Australian cities: somewhere that garbage trucks pull in, empty their loads of rubbish which is then transferred, well, somewhere else.

But in the Isséane centre, the rubbish isn't transferred anywhere. Instead, it's used as the fuel for a four-pass horizontal boiler, which produces steam – some 200 tonnes per hour of it.

About half of this steam is used to drive a turbine, which in turn drives a generator producing 52MWh of power each year – enough power for around 5,500 homes and businesses.

The remaining steam is fed into the district heating network that serves 80,000 households, saving them around 110,000 tons of heating oil each year. The waste produced by seven households can heat one family's home. The electricity tapped from the turbogenerator is used primarily for plant power; the rest is exported to the French grid.

The Isséane energy-from-waste plant consists of two process trains with a rated capacity of 30.5 tonnes per hour each, for a total of 460,000 tonnes per annum.

The waste receiving area and the combustion system are subterranean, so the plant produces neither noise nor odor emissions.

In fact, when the building was being planned, local authorities made sure that no plume would rise from the stack of the plant in Issy-les-Moulineaux, one of the most densely populated conurbation communities in Europe.

The plant meets or exceeds the tough EU standards for pollution.

The waste is incinerated on two five-zone Hitachi Zosen Inova grates. An integrated combustion control system with an infrared camera makes it possible at all times to quickly and reliably adjust the combustion parameters to rapidly changing waste compositions.

The very hot incineration gases, (the high temperature essential to prevent dioxins and other "nasties"being produced when plastics are burned), are routed through a secondary combustion chamber to

by Ross Tester

a four-pass boiler where they are cooled from 1100°C to 180°C.

Some 460,000 tonnes of rubbish is disposed of this way each year.

Apart from the electricity produced, the plant then processes the incinerated ash, washing and cleaning it for recycling into building materials after first separating any metals it contains.

Another benefit of the process is the reduction (by half) of any remaining chlorine, which is then evenly dispersed throughout the ash.

That's just a brief introduction to the French process, developed by Hitachi. We'll return to other overseas processors shortly.

It's more than a load of garbage!

Around the world, the disposal of bulk rubbish has become a major headache. We could bore you with statistics but just consider how much you throw away each week.

Sure, you diligently sort your "recyclables" into different coloured bins for the local council or contractor to pick up in special trucks for recycling – though that has an ever-increasing question mark over it according to recent reports (they say most "recycling" ends up as landfill anyway!).

But what's left, the rubbish we humans generate simply by consuming, is staggering. If you live in an urban area, think of the number of compacting rubbish trucks you see on collection days or nights.

Our local "tip" here on Sydney's Northern Beaches (woops – they like to be known as a Resource Recovery Centre these days!) receives almost a quarter of a million TONNES of waste annually.

Around 70% of that IS recycled – mainly in the area of concrete, ashphalt, aggregate and so on. Now that's a very worthwhile and laudable objective – no-one argues with re-purposing good stuff – but that still leaves 30% – or the best part of 100,000 tonnes to dispose of.

Multiply that by an almost infinite number of areas around the world and you start to get an idea of the magnitude of the problem.

And, traditionally, what hasn't been sorted into recyclables has mostly gone straight into landfill.

The latest figures suggest that around 20 million tonnes of garbage (about 40% of the 52 million tonnes of waste generated each year in Australia) makes its way into landfill sites each year. Around 75% of waste goes into just 38 landfill sites, mostly around our capital cities.

Many landfill sites around major cities have already closed – they're full·– and many more measure their life expectancy in just a few years.

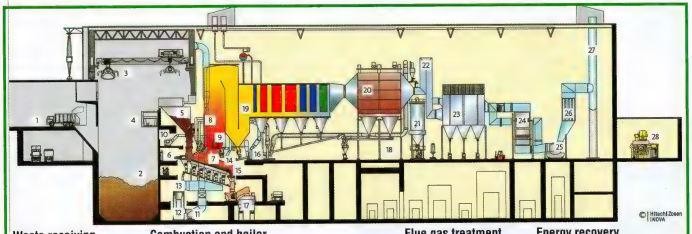
It's amazing how quickly a large landfill site can fill. When I started working in 1970, there was a *huge* brick pit just down the road from where I lived. It had just closed – they'd exhausted all the clay – so the several-acre and rather deep hole was then converted into a rubbish tip (and it stank!).

But it only took a couple of decades to be filled to the brim. These days, there are beautiful playing fields and parks covering the area . . . so where does the rubbish go now?

Other landfill sites have of course been opened – but as they fill, as they will, the authorities will find it more and more difficult to find new sites. That's due not only to much tighter laws restricting how, where and who but just as importantly (perhaps more importantly) the modern city trait of "NIMBY"ism.

In times past, many coastal cities disposed of their garbage by taking it way offshore in barges – they called them garbage scows – and dumping it in the sea (some didn't even worry about the offshore bit!). Today, that's almost a hanging offence. . .

Lately, we've seen large-scale transportation of waste from states with very high waste disposal charges (eg, NSW) to states with lower (or minimal/even no) charges (eg, Queensland). Officially they moved 670,000 tonnes last financial year; the industry believes it's closer to one



Waste receiving and storage

1: Tipping hall
2: Waste pit
3: Waste crane
4: Loader control cabin

Combustion and boiler

5: Feed hopper
6: Ram feeder
7: Hitachi Zosen Inova grate
8: Infrared camera
9: Start-up and support burners
10: Burner fan
11: Primary air fan
12: Primary air preheater
13: Primary air distribution
14: Secondary air fan
15: Secondary gir/recirculated flue gas iniection
16: Recirculation fan
17: Bottom ash transport
18: Ash conveyor
19: Four-pass boiler

Flue gas treatment

20: Electrostatic precipitator
21: Sodium bicarbonate silo
22: Flue gas entrainment duct
23: Fabric filter
24: SCR Catalyst
25: Induced-draft fan
26: Silencer
27: Stack

Energy recovery

28: Turbine and generator

The basic operation of a waste-to-energy plant. Long before any rubbish reaches the combustion furnace it is sorted to remove any non-combustibles which, where possible, are reused or recycled.

The giant Woodlawn open-cut mine near Tarago, between Canberra and Sydney, is now Australia's largest tip and is also producing electricity from landfill methane. The long-term goal is 200,000MWh each year. Notice the wind turbines on the horizon?

million tonnes. It's mainly moved by semi-trailers.

That has a three-fold effect: (a) it puts a lot of trucks on the road with attendant accidents and slowing of traffic; (b) that creates an incredible amount of diesel pollution and (c) it simply moves the problem from one place to another.

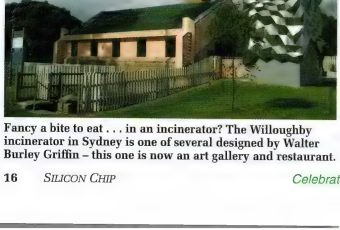
Incidentally, despite what some media (and some politicians) may tell you, it's not illegal – section 92 of the Australian Constitution allows free "trade" between states (even if the trade is in rubbish!). But legislators are said to be looking for some means of stopping it.

So landfill is frowned upon – up to a point! Dumping at sea is out. Interstate transport is not the answer. Even recycling is questionable (see panel). What to do?

Methane power generation

As an aside, even in a landfill tip, it is possible to generate power. The average domestic rubbish bin contains about 60% organic material, which breaks down over time. And as the material breaks down, it generates methane.

The now-closed Belrose tip in northern Sydney has 93 gas wells collecting this methane, providing up to 680 cubic metres per hour.



Fancy a bite to eat . . . in an incinerator? The Willoughby incinerator in Sydney is one of several designed by Walter Burley Griffin – this one is now an art gallery and restaurant.

Onsite generators fueled by this gas produces around 4MW of electricity – part of the 160MW being produced by landfill methane around Australia.

The generation, commenced in 1994, is ongoing despite no more garbage being dropped at the site. A secondary benefit is the reduction of odours from the tip – again, caused by the breaking down of the buried garbage.

The Woodlawn tip, about 200km southwest of Sydney, collects more waste than any other in the country. An old open cut mine, it's reckoned to be about one quarter full and receives waste, mainly from Sydney, by the trainload.

It too is generating methane-powered electricity – a network of pipes built layer on layer as the tip fills, so far collecting between 400 and 700 cubic metres of methane power hour, with a goal of generating up to 200GWh each year. Up to 24 generators will be built, depending on the project's success.

Incineration

Again back in history (the best part of a century ago), many councils built large-scale incinerators to dispose of (particularly) household garbage, which had previously been dumped into waterways.

Several notable incinerators were designed and built by Walter Burley Griffin, the same architect who designed Canberra (wags have claimed the purpose of both was similar).

But there are very few left these days, as councils face mounting public opposition and much stricter anti-pollution laws than were in existence in decades previous.

The Moonee Ponds (Melbourne) incinerator which opened in 1930 closed in 1942, while the Willoughby (Sydney) incinerator opened in 1934 and burnt its last garbage in 1967. Both have since been converted to art galleries and even (Willoughby) into an upmarket restaurant!

In the 21st century, however, incinerators are starting

Recycling? Or perhaps not?

Many people – most, even – refuse to believe this account when I tell it, as I have done several times. But I swear this is true because it is first hand!

Some years ago, I was involved in a bottle clean-up around a local club and we had almost filled a box trailer near the end of the day. Realising that the closest tip would close in half an hour, I called "enough" and drove the trailer to the tip and into the bottle recycling area.

This had an area for white bottles, an area for brown bottles and an area for green bottles.

I said to the attendant "I suppose you want me to sort the bottles into their colours". It was about ten minutes before closing.

"No mate, just dump them anywhere you like"

"But don't they have to be sorted for recycling?"

He guffawed and said "Recycling? This is all for show for the public and to appease the greenies. As soon as we close the gates, we pick up all the bottles with the front-end loader and take them down to bury them. We can't even give them away to the glass recyclers and even if we did, they won't come and pick them up because it costs them more in fuel than they're worth."

We can tell you that this has not changed one iota!

to make a comeback, due to the fact that the pollution restrictions, even tighter today than when the old incinerators closed, have been largely overcome with modern technology.

There is also the fact that authorities are now starting to treat rubbish, garbage, refuse, waste . . . whatever you like to call it, as a resource, not a problem. That's where the plant we opened this story with – and many more like it around the world – come into their own.

Mitsubishi's SMASH in Japan

Japan has a gargantuan waste disposal problem – in the twenty years between 1960 and 1980, it increased by five times, to more than 44 million tonnes per annum – with precious little land available for landfill.

Faced with mountains of trash, the Japanese Government revised and enforced its Waste Management Act. As a result, standards in waste management at both corporate and local government level had to improve – with the result that some of their procedures are now the most advanced in the world.

The refuse centre in Iwate-Chubu, in north-eastern Honshu, Japan, is typical; a showcase of modern waste management – and the technology is now used in many similar installations in operation, or being built, around the world (except, regrettably, in Australia!).

It utilises both advanced resource recycling systems and the SMASH system to re-purpose as much of the incoming waste as possible, even using the ash produced by the incineration process as one of the raw materials for cement.

To achieve a high level of heat recovery during incineration, an advanced technology called Internal Gas Recirculation (IGR) is employed as a secondary combustion air supply. It combines recycled combustion gas from the furnace with a rich supply of oxygen to feed the furnace during combustion.

This enables the furnace to operate with a lower ratio of air, not only improving efficiency but reducing the amount of exhaust gas.

In addition, the higher level of heat recovery increases the amount of electricity generated from each tonne of waste by two or three percent compared to conventional furnaces.

And Hamm in Germany

The waste plant in the city of Hamm, Germany, was designed for the incineration of municipal waste. It mainly handles domestic waste but also commercial waste and bulky refuse.

Originally commissioned in 1985, the Hamm plant has had several extensions, which have increased the incineration capacity to 295,000 tonnes/year.

Each of the four identical combustion lines has a throughput of 10 tonnes per hour. Normally, combustion is completely self-sufficient, without the need for supplementary fuels such as paper, etc.

The heat of the flue gas produced during combustion is used to generate steam, which is fed to the three turbogenerators for power generation (approximately 26MW installed capacity).

With the aim of maintaining the waste disposal operations at a high technical level and to meet tighter environmental regulations, the plant was retrofitted and upgraded in several stages.

In the USA

In 2015, the last year for which data is available, there were 71 waste-to-energy power plants and four other power plants in the United States which burned what they term MSW: Muncipal Solid Waste. There are obviously many more now.

These plants burned about 29 million tons of MSW in

The Iwate-Chubu plant in north-east Japan which burns 56.000 tonnes each year and as well as producing electricity, its SMASH technology recycles most of its ash.

The Hamm, Germany waste-to-power plant with an installed capacity of 26MW. It burns almost 300,000 tonnes of waste each year.

An energy-from-waste plant for Sydney?

Architect's impression of the Eastern Creek plant

In 2015, then again in 2017, the CEO of Dial-a-Dump industries, Ian Malouf, proposed the world's largest power-generating incinerator to be built on land (actually an existing landfill site) the company owned at Eastern Creek, in Sydney's western suburbs.

The facility would be co-sited with its existing "Genesis" recycling facility and would, in fact, take all of its input from that facility.

He has formed a company called TNG: The Next Generation, to develop and operate the plant, the first in Australia.

Their aim is to dramatically reduce the generation of greenhouse gases and to help solve the energy needs of Western Sydney over the next fifty years.

The $700 million plant would take mainly building and construction waste, separate it into fully recyclable materials (eg, road base, aggregate, etc) and then incinerate the remainder, using state-of-the-art furnaces which almost eliminate any smoke exhaust.

This plant would initially treat about 530,000 tonnes of waste each year, rising to more than 1.1 million tonnes after proving itself. Along the way, it would produced the steam for turbines which would generate enough energy to power 100,000 homes (rising to 200,000).

However, despite growing concerns about power prices, power station closure and the possibility of blackouts, it has had a very loud "anti" backlash from the community. Much of the opposition appears to have been fed by deliberate misinformation campaigns.

Project stalled against local opposition

The local Blacktown and Penrith councils, Western Sydney's Local Health District, Labor, the Greens and even the Government's Environmental Protection Authority have all come out in opposition to the proposal.

It must be said that the EPA's arguments were more along the "insufficient evidence" line than the sometimes spurious reasons other groups gave.

NSW Health's main objection was that it was twice the size of any similar plant anywhere in the world, while the Greens claimed that it would "reduce recycling rates, spew out air pollution and impact on the health of residents."

The attitude of the Greens is puzzling, given their party's anti-landfill policy. The TNG proposal would reduce landfill by between eighty and ninety percent. . . yet they oppose it!

Some community groups, as might be expected, have even displayed placards reading NIMBY – Not In My Back Yard.

However, Mr Malouf told Fairfax Media that despite the objections, he remained confident "that the project represents a positive environmental outcome".

"The facility will process only residue building, commercial and demolition waste that is currently being landfilled," he said. "It will provide a secure, long-term supplement to western Sydney's energy demands."

He said that more than 2200 facilities in urban areas, alongside homes, schools, shops and businesses across 35 countries are already using the same safe and efficient thermal technology, to generate power.

These facilities have all passed rigorous approval processes and for many years have been producing clean, cheap energy, with less harm to the environment, compared with coal fired stations or by dumping waste into landfill.

Dial-a-Dump has commissioned independent research into the proposal, which found that 69% of respondents supported the concept of energy from waste.

The future

The proposal is currently back before the State Government, probably for a decision early this year.

Even with a "sweetener" by TNG of free solar power panels for 1000 homes closest to the site (bear in mind that the closest house is more than 800m away), there is no guarantee that the locals' NIMBY attitude or the "object to anything" philosophy of the Greens will change.

Time will tell!

And another one for Mt Piper?

As we went to press (late December 2017) a proposal was released for another energy-from-waste scheme, this time for the 1400MW Mt Piper power station, located about 100km west of Sydney near the town of Lithgow.

The proposal, named Refuse Derived Fuel (or RDF) called for the conversion of part of the Mt Piper plant to burn selected materials, including paper, plastics, disused linen, etc which would otherwise go into landfill. It would have the capacity to generate about 27MW and use an estimated 200,000 tonnes of refuse annually.

Energy Australia, owners of Mt Piper, were conducting the study in conjunction with the recycling management company Re.Group.

The project would cost around $60 million, take 12-18 months to build and originally claimed could be generating its first power as early as 2019, although this appears to have blown out to 2021.

Energy Australia claimed there were significant environmental benefits in the project, as materials that would be used in the energy recovery project would otherwise go to landfill.

While having a nominal life until the middle of the century, the future of Mt Piper has been under somewhat of a cloud since the green activist group "4nature" successfully launched action in the NSW Land and Environment Court against the NSW Government's 2015 planning consent for the extension of the Springvale Colliery (one of Mt Piper's main coal sources) on the basis that it could contaminate water catchments in the Blue Mountains area.

Without an assured supply of coal, Mt Piper faced cutback or even closure, which would take a further 15% of supply out of the east coast electricity market. This came not long after the news that AGL's 2000MW Liddell power station will close in 2022.

The Energy Australia/Re.Group study, due to be completed about now, would be looking at the project from the economic viability and benefits side (eg, the extra power produced) but also the negative side (environmental impact in particular).

Even before the study was complete, environmental groups were condemning the proposal, with bodies such as the Colong Foundation saying it was the "wrong step for diversifying sources of power". The Colong Foundation has a "zero waste" policy so burning refuse to produce power goes counter to their code. They also claimed the plant would give off "highly toxic pollutants" and the ash produced would pose a risk to waterways, including the Coxs River, part of the Sydney water supply catchment.

The 1400MW coal-fuelled Mt Piper power station near Lithgow, NSW faces a somewhat uncertain future.

2015 and generated nearly 14 terrawatt-hours of electricity (10^{12} Watts!).

The biomass materials in the MSW that were burned in these power plants accounted for about 64% of the weight of the MSW and contributed about 51% of the energy. The remainder of the MSW was non-biomass combustible material, mainly plastics.

As we mentioned earlier, many large landfills are also generating electricity by using the methane gas that is produced from decomposing biomass.

Where to from here?

The rest of the world is forging ahead with garbage-to-power plants, alleviating three problems: avoiding landfill, generating power and using up resources for building materials.

In Australia, the future is not so rosy, with obstacles being placed at every turn for the proponents of garbage-to-power plants.

Many of the arguments put forward are spurious in the extreme. Many appear to represent the current view of "if it moves, object to it". Of course, in amongst the garbage (no pun intended) there may be some elements of truth, which from our reading the company has tried to answer.

But for the rest, the old adage applies: "why let the facts get in the way of a good story."

Only time will tell.

Further media

There is a considerable amount of information on the internet regarding energy from waste. Some of these are obviously "puff pieces" written by PR companies and/or newspaper journalists with very little knowledge of the subject they are writing about.

But they at least give some interesting facts, which you might like to peruse.

All of the URLs are shown here in the form of *Silicon Chip ShortLinks*, which will take you direct to the URL in question. If you're looking at Silicon Chip OnLine, simply clicking on any of them will do the same thing.

For a start, the Isséane (Paris) transfer station shown at the start of this report is featured in some TV commercials by NextGen – you may have seen them on late-night TV: **http://siliconchip.com.au/l/aahy**

The Japanese plant mentioned here is featured in a report by Mitsubishi: **http://siliconchip.com.au/l/aahz**

If you really have plenty of time on your hands (!), read through Nextgen's almost 400-page environmental impact statement answering many of the questions raised by the authorities and by objectors: **http://siliconchip.com.au/l/aai0**

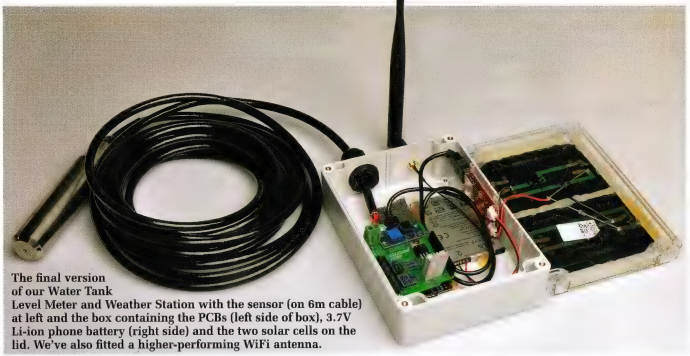
And there are various media and newsletter reports which also give interesting background:

http://siliconchip.com.au/l/aai1
http://siliconchip.com.au/l/aai3
http://siliconchip.com.au/l/aai4
http://siliconchip.com.au/l/aai5
http://siliconchip.com.au/l/aai6
http://siliconchip.com.au/l/aai7
http://siliconchip.com.au/l/aai8

Solar Powered WiFi Water Tank Level Meter and Weather Station

by Nicholas Vinen

The level in some water tanks is easy to check – but others, especially if they're high up, or remotely located, or have difficult access, can be the proverbial pain in the *#@^! Here's a great way to check your tank level(s), and you don't even need to be on the same planet (OK, slight exaggeration) to do so. Just call this unit up from anywhere and get an instant reading . . . and a weather report into the bargain!



The final version of our Water Tank Level Meter and Weather Station with the sensor (on 6m cable) at left and the box containing the PCBs (left side of box), 3.7V Li-ion phone battery (right side) and the two solar cells on the lid. We've also fitted a higher-performing WiFi antenna.

This Arduino-based unit runs from solar power and periodically uploads your water tank level and outdoor temperature, humidity and barometric pressure to a "cloud" service.

You can check the data at any time from anywhere, using a mobile phone, tablet or PC. It even provides graphs to show you how these readings change over time.

We've published numerous water tank level meter projects in the past but this one has to be the easiest to build, set up and use.

That's because it takes advantage of an off-the-shelf pressure-based water level sensor which comes already waterproofed, with a long lead attached.

So you just need to drop it down into the tank, hook it up to the Arduino-based unit and it will automatically upload the tank level to "the cloud". You can then check it anywhere in the world, at any time.

We figured that while we were going to the trouble of doing this, we might as well also measure the local temperature, humidity and barometric pressure too.

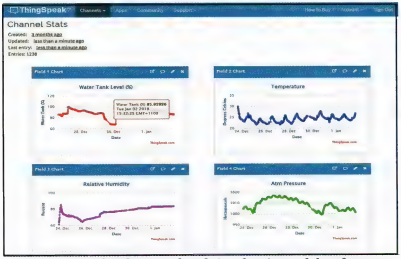
This adds very little to the project cost but it means you can check what the local weather is like at any time – even when you aren't anywhere near your tank/home/office . . . anywhere!

More than one tank to check?

Lucky you . . . but if you have multiple water tanks to check, that's no problem. Just build multiple units, set up a separate "channel" for each one and Bob's your uncle.

And because we've based it on an Arduino-compatible module, the software is nice and simple and you could modify it if you have any special needs.

For example, you could change the interval at which the water level is checked. If you have some programming skills, you could even make it switch a pump on or off, depending on the water level.



A screen grab of the ThingSpeak website, showing real data from our test unit monitoring a rain water tank.

Circuit description

The circuit for the Water Tank Meter/Weather Station is shown in Fig.1. It's based on an ESP8266 Arduino-compatible board. This incorporates the WiFi transceiver and it's very easy to get it connected to the internet.

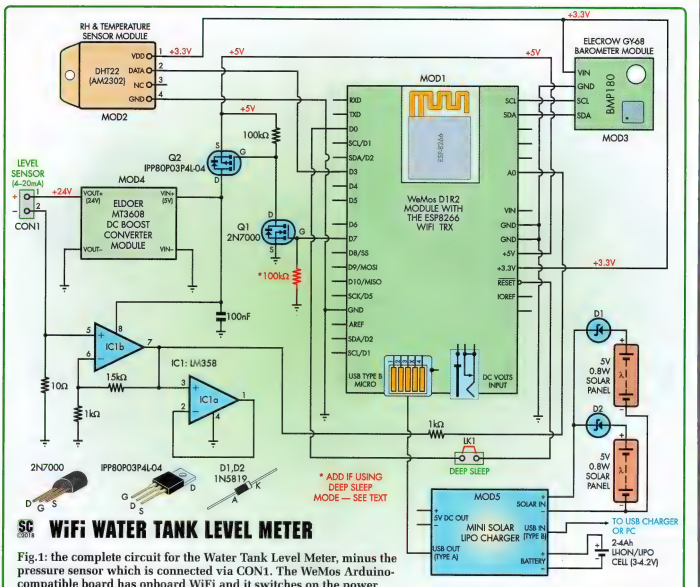
The waterproof pressure sensor connects across terminal block CON1. These are available from eBay and AliExpress and can measure water levels up to about 6m (that may vary between products).

They simply need to be dropped into the tank (eg, through a hole in the top) so that they sit on the bottom and can monitor the water pressure there.

These sensors operate using the 4-20mA current loop principle and require a 24V DC power supply.

Basically, the sensor will draw between 4mA and 20mA from the power supply, depending on the sensed pressure (and thus water level).

If exposed to air, at normal atmospheric pressures, the current will be around 4mA and under the maximum



WiFi WATER TANK LEVEL METER

Fig.1: the complete circuit for the Water Tank Level Meter, minus the pressure sensor which is connected via CON1. The WeMos Arduino-compatible board has onboard WiFi and it switches on the power supply to the sensor when necessary, then measures its output via op amp LM358 at analog input A0. The digitised value is sent to a cloud database host service.

rated depth of water, the current will be around 20mA.

This means that the sensor needs only two wires and these provide power to the unit and also carry the output signal.

And because the output signal is a current, the resistance of the long wires or any connections along the way will not affect the reading.

It does lead to two problems though: One is how to provide 24V to the sensor when the Arduino board runs from 3.3V/5V and do it in a manner which doesn't drain the small battery too quickly. And the other is how to measure the sensor's supply current using the ESP8266.

The first problem is solved by using a low-cost MT3608 voltage boost module. This is quite small at 50x21mm, costs just a few dollars and can produce an output of up to 38V with a 3.2-32V input at up to 2A.

Its efficiency under load is quite good, around 90%. But to save battery power, we will only power up the MT3608 when making the periodic water level measurement.

We chose to measure the current using a simple method. We insert a 10Ω resistor in series with the sensor's ground connection. With 4-20mA flowing through that portion of the circuit, the voltage across this resistor will be 40-200mV. This reduces the sensor's supply voltage but it will still work fine at 23.8V and we can easily compensate by adjusting the boost module to produce 24.2V anyway.

Those voltages are a little low to measure directly using the Arduino module, so we provide 16 times amplification using op amp IC1b.

This is a standard LM358 single-supply op amp which will happily run off the 5V supply. The gain is set by the ratio of the 15kΩ and 1kΩ feedback resistors.

Its output is 600-3000mV, ie, 0.6-3V and this is fed to analog input A0 on the Arduino via a 1kΩ resistor.

This resistor isn't absolutely necessary but since the LM358 op amp runs off 5V and the Arduino's supply is 3.3V, there is a remote possibility that the Arduino input could be over-driven. In this case, the resistor limits the current to a safe level.

However, LM358 outputs normally

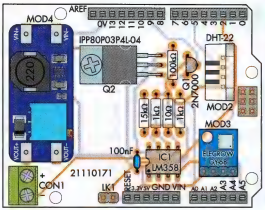


Fig.2: PCB overlay for the Water Tank Level Meter Arduino shield PCB with a matching same-size photo at right. Fit the components where shown, starting with the lowest profile parts and working your way up to the taller ones.

can only vary up to 1.5V below the positive supply rail, which in this case is nominally 3.5V and thus likely safe.

Andthe op amp's output current is internally limited to around 40mA. Still, the 3.3V and 5V rails can vary by a few hundred millivolts either way so the 1kΩ resistor is a worthwhile and cheap measure to ensure reliable operation.

The ESP8266 ADC has a 10-bit resolution (the same as most Arduinos) and so this 0.6-3V level will normally translate into digital readings of around 186-930 for 0-100% of the pressure sensor's range.

That will give a resolution of around 0.13% to the readings [ie, 100 ÷ (930 – 186)].

But keep in mind that a typical water tank is not 6m high, so the resolution will be reduced proportionally. Still, you can expect it to be no worse than half a percentage point.

By the way, note that the ESP8266 only has one analog input (A0), compared to the normal six on an Arduino Uno – one of its few weaknesses.

Remainder of the circuit

As mentioned earlier, the power supply for the water level sensor is only powered up when the sensor is actually being used.

This is done by driving digital output pin D7 of MOD1 high, which drives the gate of N-channel small signal Mosfet Q1 high.

This is a 2N7000 logic-level Mosfet so the 3.3V at its gate is sufficient to switch it on, pulling the gate of P-channel Mosfet Q2 low.

Q2 is a high-current logic-level device and its gate is normally held at +5V by a 100kΩ pull-up resistor, keeping it off. But when Q1 switches on and pulls its gate low, current can flow from the 5V supply to the VIN+ terminal of MOD4, the boost regulator. It will then generate 24V to drive the water level sensor.

Note that there are two voltage level translations occurring with this arrangement; from the 3.3V swing of the output of MOD1 up to a 5V swing at the gate of Q2, and then a 24V change in the output of MOD4.

If the sensor is drawing 4mA (ie, the water tank is empty) then you can expect at least 19.2mA (4mA x 24V ÷ 5V) additional drain on the battery.

In practice, it will be closer to 25mA. With a full water tank and the sensor drawing 20mA, this will increase to over 100mA.

So it's a good thing that it only needs to be powered up for a second or so each time a measurement is made or the battery would be flat in a few hours.

When the power supply for the sensor is off, there is no current flow and so no voltage across the 10Ω resistor. Therefore output pin 7 of IC1b is at 0V and so is analog input A0 of MOD1.

The ESP8266 has a built-in WiFi transceiver so we don't need to add anything extra to the circuit in order to transmit the water tank level over the internet.

Weather station

Since this unit is likely to be placed outdoors, we thought we might as well add a couple more low-cost components to allow it to monitor ambient air temperature, pressure and humidity.

ESP8266 Arduino pin numbering

One of the most challenging aspects of developing the software for this project was dealing with the strange way the digital pins are numbered on the WeMos D1 R2 board. If you plan on modifying the software, you will need to be aware of this.

For a start, there's the incorrect labelling on some PCBs that was mentioned in the text. On some WeMos boards, the TX and RX pins are labelled "0" and "1" (despite not being usable as such) and consequently, the actual D0 pin is labelled 2, D1 is labelled 3 and so on.

But even more confusing is the fact that the digital pins are not connected to pins with a matching number on the IC while others have built-in pull-up or pull-down resistors.

And it appears that some of the digital pins are not usable at all!

The following table indicates which pin numbers you actually need to use in the software (ESP8266 pin) to access one of the Arduino digital pins. It also shows which pins have special functions or pull-up/pull-down resistors.

Arduino pin	ESP8266 pin	Additional functions
D0	16	
D1	5	SCL
D2	4	SDA
D3	0	10kΩ pull-up
D4	2	10kΩ pull-up, BUILTIN_LED
D5	14	SCK
D6	12	MISO
D7	13	MOSI
D8	15	SS, 10kΩ pull-down

Parts list – Water Tank Level Meter +

1 4-20mA water level (pressure) sensor with cable [Silicon Chip Online Shop Cat SC4283]
1 double-sided PCB, coded 21110171, 68.5 x 53.5mm
1 set of four long-pin Arduino stackable headers (included with PCB)
1 WeMos D1 R2 ESP8266-based Arduino board (MOD1) [Silicon Chip Online Shop Cat SC4414]
1 DHT-22/AM2302 temperature/humidity sensor module (MOD2) [Silicon Chip Online Shop Cat SC4150]
1 GY-68 temperature/barometric pressure sensor module (MOD3) [Silicon Chip Online Shop Cat SC4343]
1 MT3608-based 2A boost regulator module (MOD4) [Silicon Chip Online Shop Cat SC4437]
1 2-way mini terminal block (CON1)
1 2-way pin header with jumper shunt (LK1)
1 4-pin header (for MOD3)
1 M3 x 6mm machine screw and nut
2 small solar panels, around 1W each, 6V open-circuit, approximately 100 x 70mm (SILICON CHIP online shop Cat SC4339)
1 Elecrow mini solar charger module (MOD5) [Silicon Chip Online Shop Cat SC4308]
1 JST-2.0 2-pin plug with flying leads (included in SC4308)
1 short USB Type A to micro Type B cable
1 single Li-ion cell, 2-4Ah
1 IP65 sealed case with clear lid [eg, Jaycar HB6248 (171 x 121 x 55mm) or Altronics H0330 (186 x 146 x 75mm)]
1 cable gland to suit 7mm diameter cable [eg, Jaycar HP0724, Altronics H4312A]
1 chassis-mounting 2.4GHz WiFi antenna with cable and U.FL/IPX connector (optional) [SILICON CHIP Online Shop Cat 4522 or 4523]
1 small piece open-cell foam (eg, 25 x 25 x 10mm)
1 150ml or 300ml cartridge of clear neutral cure silicone sealant
a few short lengths of light-duty hookup wire

Semiconductors
1 LM358 dual op amp, DIL package (IC1)
1 2N7000 N-channel Mosfet (Q1)
1 IPP80P03P4L-04 P-channel logic-level Mosfet (Q2) [Silicon Chip Online Shop Cat SC4318]
2 1N5819 schottky diodes (D1,D2)

Capacitors
1 100nF MKT or ceramic

Resistors (all 0.25W, 1% metal film)
1 100kΩ 1 15kΩ 2 1kΩ 1 10Ω

These are be logged to "the cloud" along with the water tank levels, so you can see what the weather is like, even if you aren't at home (or on the farm, or wherever your water tank is located).

MOD2 is a DHT-22 temperature/humidity sensor. We described the operation of this device in the El Cheapo Modules 4 article, published in the February 2017 issue.

It uses a single wire protocol for communications and this goes to digital I/O pin D3 of MOD1.

MOD3 is a GY-68 barometer module based on the BMP180 temperature/pressure sensor.

This has also been described in one of our El Cheapo Modules articles, this time part 11 in the December 2017 issue. Its communication is via I²C so the clock (SCL) and data (SDA) lines are hooked up to the I²C interface pins on MOD1.

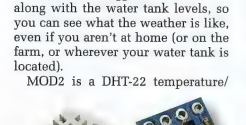
The ESP8266 chip can query these sensors immediately before taking a water tank level measurement and sends the measurements to the remote database at the same time. This has a minimal effect on battery life and network traffic.

The electronics will need to be mounted in a weatherproof enclosure and/or sheltered position to protect it from rain, etc.

But for MOD2 to measure humidity and MOD3, atmospheric pressure, they can't be in a completely sealed box. We'll go over some potential solutions to this apparent contradiction later.

Note also that, given that the unit is powered by solar panels which need to be in the hot sun, and given that there is some dissipation from the unit itself, the temperature readings are likely to be on the high side on a sunny day.

There are some steps you could take to mitigate that, such as installing a small fan to ensure air movement through the enclosure, but we won't go into great detail on this aspect of the design as the weather data is not meant to be at a BoM level of accuracy.



(Left) the DHT22 digital temperature and humidity sensor, with the Barometric Pressure/Altitude/Temperature I²C Sensor board at right.

Power supply circuitry

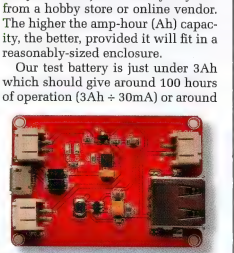
We're using a similar power supply as we did with our Arduino Data Logger (August-September 2017).

As with that design, we're using the Elecrow Mini Solar Charger module (MOD4) which provides a regulated 5V supply for the Arduino at its USB output socket.

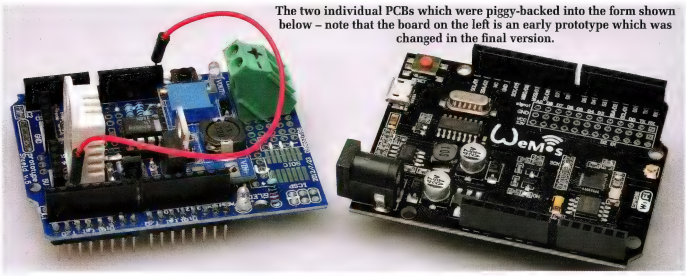
This is derived from a single Lithium-ion cell (3-4.2V).

Once again, we're using a battery salvaged from an old mobile phone – but you could just as easily buy one from a hobby store or online vendor. The higher the amp-hour (Ah) capacity, the better, provided it will fit in a reasonably-sized enclosure.

Our test battery is just under 3Ah which should give around 100 hours of operation (3Ah ÷ 30mA) or around



The Elecrow Mini Solar Li-ion Charger module, reproduced same size.



The two individual PCBs which were piggy-backed into the form shown below – note that the board on the left is an early prototype which was changed in the final version.

four days. The battery is charged from two small (<1W) solar cells, with an open-circuit output voltage of around 6V. They are effectively paralleled using a pair of schottky diodes, D1 and D2.

These are included so that if one panel has sun while the other is shaded (eg, due to the shadow of a tree, the water tank etc), there will still be enough voltage supplied to the charger module for it to operate.

The forward voltage of these diodes will slightly reduce the available power when both panels are in full sun but we think there's a good chance they will increase the total power available over the course of a day in a typical installation.

If we get an average power of say 1W from the panels for an average of eight hours a day in winter, that 8Wh translates into around 1.5Ah at 5V. Given the ~30mA average current drain of the unit, that should allow it to operate for around 50 hours.

While that's around twice the actual power required, of course, there will be cloudy days and so on, so the excess capacity can go into recharging the battery.

Hence, we would not recommend using a smaller set of solar panels than shown here (in fact, more/larger would be better).

If you have access to a mains supply near your water tank, you could connect a USB charger to the "USB IN" socket on MOD4 and this will then run the circuit and keep the battery charged.

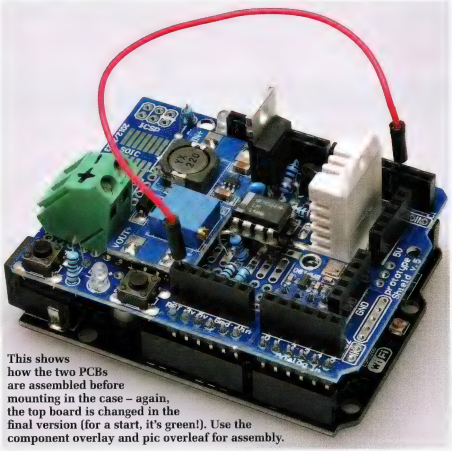
The battery would then run the unit during blackouts and the solar panels would not be necessary.

Link LK1, labelled "DEEP SLEEP", is connected between the RESET input on MOD1 and digital output pin D0. See the separate panel explaining the purpose of this link and what you need to do to be able to use it. Most constructors will probably leave it open.

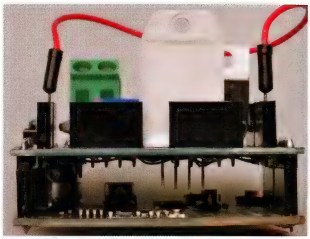
Optional but recommended external antenna

While we said earlier that the ESP8266 doesn't need any extra components to operate over a WiFi network, given that the unit will almost certainly be located outdoors and possibly some distance from your network, there's a chance that the onboard PCB track antenna simply won't be good enough to pick up your WiFi signal.

Fortunately, the WeMos board has provision for attaching an external 2.4GHz antenna via a tiny onboard U.FL/IPX RF connector.



This shows how the two PCBs are assembled before mounting in the case – again, the top board is changed in the final version (for a start, it's green!). Use the component overlay and pic overleaf for assembly.



This end-on view also shows the method of construction. On the bottom is the Arduino WeMos ESP8266 Arduino board, with the top board a shield designed specifically for the project.

There are various different antennas available that suit the 2.4GHz band and while they typically have an SMA plug at their base, many of them are supplied with an adaptor cable consisting of a chassis-mount SMA socket at one end and a U.FL/IPX connector at the other.

Two suitable antennas are available from the SILICON CHIP Online Shop (see parts list).

One has 5dBi gain and is vertically polarised, and is able to be rotated and bent at an angle for optimal reception. The other has 2dBi gain but is smaller and omnidirectional.

Both are supplied with suitable adaptor cables that will plug right into the ESP8266 board.

Or you could source a suitable antenna yourself.

And both of our antennas are waterproof so can be mounted on the outside of the case and the connectors sealed with silicone sealant to prevent water from getting inside.

Construction

As you can see from the photos, our prototype was wired up on a protoboard shield. The circuit is certainly simple enough to do this, involving only about a dozen components, and it only takes a couple of hours to wire it up.

But it's much easier if you build it on a printed circuit board, which is why we've designed one and had it manufactured. The overlay diagram for this PCB is shown in Fig.2.

Fit the five resistors in the positions shown. Even though we've shown their colour codes in the table, we suggest you check the values using a DMM before soldering as the colour bands are easy to misread.

Follow with IC1; use a socket if you want to but make sure its pin 1 dot is orientated as shown.

Next, bend the leads of Q2 so they fit through the board and its tab hole lines up with the corresponding hole in the PCB. Then fasten the tab to the PC using a 6mm M3 machine screw and nut before soldering and trimming the leads.

Follow with the 100nF capacitor and then Mosfet Q1. Its flat face must be orientated as shown in Fig.2.

Next, fit terminal block CON1 with its wire entry holes facing towards the nearest edge of the board. Then solder modules MOD2 and MOD3, with the orientations shown. You will need to fit a 4-pin header to MOD3 before soldering it to the board.

MOD4 can then be mounted to the board, using component lead off-cuts (or tinned copper wire). Solder the four wires to the board, then feed them through the holes on the module and push it down before soldering it in place.

Finally, fit the four long-pin headers in place along the edge of the PCB, with the socket parts on the top of the board and the pins projecting from the bottom. To do this, you need to solder around the bases of the pins, where they emerge from the bottom of the board.

Setting the sensor voltage

Before programming the Arduino board, it's a good idea to adjust MOD4 to give a sensor supply voltage of around 24.2V.

It's easier to do this before the software is loaded because that software will shut down the sensor supply most of the time, to save battery power.

Plug the finished shield into the WeMos Arduino board and then connect a spare resistor between pin D7 and 5V. You can do this by plugging the resistor leads into the sockets on top of the shield board.

We must caution you that pin D7 is not correctly labelled on all WeMos D1 R2 boards. It's the ninth digital pin, ie, the second one located on the second 8-pin header on that side of the board. Our WeMos board incorrectly labelled the digital pins 0, 1, 2, 3, ... rather than the correct labelling, which should be

Deep Sleep Mode

If link LK1 on the board is bridged, changing the line at the top of the code from "//#define USE_DEEPSLEEP" to "#define USE_DEEPSLEEP" should theoretically reduce overall power consumption. However, the effect is quite small and doing so has some disadvantages.

With LK1 in circuit, the ESP8266 IC is able to completely shut down its CPU while in sleep mode. A special timer is included in the ESP8266 IC which drives pin D0 low after a certain time has elapsed, which resets the chip, waking it up and allowing the software to start again.

The reason that this doesn't save a whole lot of power is that the regulators and other circuitry onboard the ESP8266 Arduino module remain powered up, even though the chip itself is in deep sleep mode. And IC1, MOD2 and MOD3 continue to draw power too, albeit not very much (under 1mA total).

The actual reduction in current is just a few milliamps, increasing battery life by a few percent.

But because the chip is reset each time, it can't keep anything in RAM during the sleep time and this affects the code's ability to reliably determine the water tank minimum and maximum levels.

The software feature intended to prevent sensor glitches from affecting the detected minimum and maximum levels is automatically disabled if deep sleep mode is used.

Also, if deep sleep is enabled, you need to fit a pull-down resistor at the gate of Q1 as the I/O pin states are no longer under the control of the ESP8266 micro in deep sleep mode. This resistor can be plugged into the header sockets on the board, between D7 and the nearby ground pin.

We don't think the small power saving is worthwhile but you can perform the steps mentioned above if you want to try it.

TX, RX, 0, 1, 2, 3, ...

Having done that, plug the board into your PC's USB port and measure the voltage between VIN+ and VIN- on MOD4. You should get close to 5V.

Now measure the voltage at the output and adjust the onboard trimpot until it's close to 24.2V. Note that you will need to turn the trimpot screw anti-clockwise to increase the voltage (counter-intuitively).

When finished, remove the extra resistor you plugged in earlier.

Should you need to re-adjust this output voltage when the software is loaded, MOD4 will be powered up for a few seconds each time the unit boots up, so you can press the RESET button and quickly measure the output voltage before tweaking the adjustment screw.

Or alternatively, unplug the shield and apply 5V via its interface pins, with the extra resistor connected as described above.

Loading the software

Now unplug the shield from the WeMos ESP8266 Arduino board and re-connect it to your PC using a USB cable, so you can load the software.

The Arduino sketch is a .ino file and it can be downloaded from the SILICON CHIP website (free for subscribers).

The download package (zip) also includes the required libraries to build it but you will also have to download and install the ESP8266 board files onto your PC.

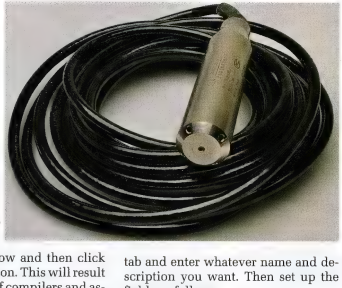
First, install the latest version of the Arduino IDE, if you don't already have it. This can be downloaded free from **www.arduino.cc/en/Main/Software**

Next, install the ESP8266 board files. This is also a free download but it's quite large and will take a while. To do this, open up preferences in the Arduino IDE and under "Arduino Board Manager URLs", enter:

```
http://arduino.esp8266.com/stable/
package_esp8266com_index.json
```

Hit OK, then go to Tools -> Boards -> Board Manager, type in "esp8266" in the search box, click on the entry which appears below and then click on the "Install" button. This will result in around 160MB of compilers and associated files being downloaded and installed on your computer.

The "heart" of this project is the purpose-designed water sensor, as shown here. It is rated to measure up to 5m depth (so can handle a pretty large tank!) and comes complete with a 6m cable. Like the other specialised components in this project, it is available from the SILICON CHIP Online Shop (Cat SC4283).



You can now go to the Tools -> Board menu and select the "WeMos D1 R2 & mini" entry from the drop-down list. Next, install the supplied libraries using the Sketch -> Include Library -> Add .ZIP Library option, if you didn't have them already.

Setting up a ThingSpeak channel

When the unit is operational, the water tank level, temperature, humidity and barometric pressure will be logged periodically to a free internet host called ThingSpeak.com.

They store this data in their database and you can then log in and view and plot the data from anywhere in the world. You can also make the plots publically available.

Before you finish loading the software, you will need to go to **www.thingspeak.com** and set up a free account (if you don't already have one).

You will also need to set up a "channel", which the data will be associated with.

Basically, channels let ThingSpeak users track multiple, different sets of data.

Create a channel via the website, then click on the "Channel Settings" tab and enter whatever name and description you want. Then set up the fields as follows:

* Field 1 – "Water Tank Level (%)"
* Field 2 – "Temperature (C)"
* Field 3 – "Humidity (%)"
* Field 4 – "Atm Pressure (hPa)"
* Field 5 – "Water Tank Level (raw)"
* Field 6 – "Temperature 2 (C)"
* Field 7 – "Min Tank Level (raw)"
* Field 8 – "Max Tank Level (raw)"

You can change these names if you want to, the above is only a guide as to what you need. You can enter the elevation, latitude and longitude of your water tank if you want so that the website can show the location where the data is coming from on a map.

Having set that all up, click on the "API Keys" tab and make a note of the Channel Number and Write API Key. Next, open up the sketch and modify it so that it can connect to your WiFi network.

Near the top of the file, you will see four lines similar to the following:

```
//Constants
char WiFiSSID[] = "xxxx";
char WiFiKey[] = "yyyy";
unsigned long myChannelNumber = 1234;
const char * myWriteAPIKey = "zzzz";
```

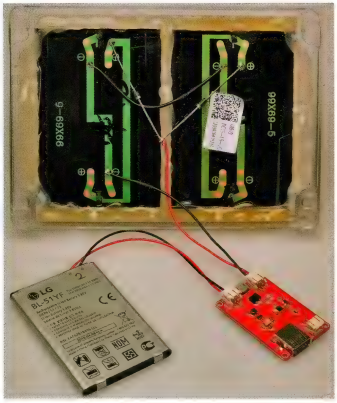
Change the WiFiSSID[] and WiFiKey[] strings (shown as xxxx and yyyy here) to suit your WiFi network. Then set the myChannelNumber and myWriteAPIKey values to match those you noted earlier when setting up your ThingSpeak account.

You can then compile/verify the sketch (CTRL+R) and it's ready to be uploaded to the WeMos board (CTRL+U).

Note that the compile/verify stage

Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑ 1	100kΩ	brown black yellow brown	brown black black orange brown
❑ 1	15kΩ	brown green orange brown	brown green black red brown
❑ 2	1kΩ	brown black red brown	brown black black brown brown
❑ 1	10Ω	brown black black brown	brown black black gold brown



The solar-powered charger consists of a pair of 100 x 70mm solar cells connected in parallel, an Elecrow mini solar charger module (solar cells and charger are available from the SILICON CHIP Online Shop) – see www.siliconchip.com.au/shop –and 3.7V Li-ion battery pack (we salvaged ours from a mobile phone). A pair of schottky diodes in series with the solar cells prevent the cells from loading each other when in partial shade.

can take some time (one minute or longer) and the upload process will only start if the compile/verify was successful. If it is successful, you should get a message like the following:

```
Sketch uses 241,141 bytes (23%) of
program storage space.
Maximum is 1,044,464 bytes.
Global variables use 33,292 bytes
(40%) of dynamic memory, leaving
48,628 bytes for local variables.
Maximum is 81,920 bytes.
```

If there are any errors during this process, messages will appear at the bottom of the Arduino IDE instead, indicating the problem.

The most common problem would be if one of the required libraries has not been installed or you already had a conflicting library installed (eg, an old version).

Other possible problems are the wrong Board selection or an incorrect change when setting up the WiFi network and channel details.

Assuming the code is successfully compiled and uploaded, unplug the ESP8266 board from your PC and plug the shield into it. You are then ready for a proper test.

Testing

Initial testing can be done by simply plugging the shield into the programmed WeMos Arduino board and applying power via the USB cable from your PC. Not only is this convenient but it also means you can monitor the debugging messages in case something goes wrong

With the Arduino IDE open, plug the WeMos board into your PC's USB port and then open the Serial Monitor by pressing CTRL+SHIFT+M (in Windows) or via the Tools -> Serial Monitor menu item.

If the Serial Monitor doesn't open, eg, you may get a message such as "Board at COM7 is not available" at the bottom of the IDE window, you need to select the correct serial port via the Tools -> Port menu option.

Then try opening the Serial Monitor again.

Once it's open, make sure the baud rate is set to 115,200 and then press the reset button on the WeMos board.

It's in the corner, next to the USB socket. You may see some "garbage" characters on the Serial Monitor, and then you should get a display like:

```
ESP8266 in normal mode
.....
WiFi connected
192.168.0.43
min = 450, max = 450
Uploading data...
Done.
```

If, after the "ESP8266 in normal mode" message, all you see is an ever-increasing row of dots, that's a sign that the unit is unable to connect to your WiFi network. This could be due to the SSID or encryption key being set incorrectly in the sketch, so check them carefully.

If they are correct, you may need to change your router settings to allow the unit to connect (eg, by adding its MAC address to the list of allowed addresses).

Or it may be that you've set up your router to use an encryption scheme that the ESP8266 does not support. Our router is set up for the modern "WPA2-PSK (AES)" method and it works fine.

If your device connects to WiFi OK but you get "Error." rather than "Done." then that means there was a problem uploading the data to ThinkSpeak. Check that you have set the correct channel number and Write API Key.

Assuming it's working, you can log into the ThingSpeak website and see the (for now, incomplete) data. The charts in your channel will automatically update a few seconds after new data arrives.

If you wait long enough (around 10 minutes), you should see the device wake up and then send another set of data points over your WiFi network.

Note that the water tank level percentage figures will be invalid because the sensor is not attached and it has not been calibrated yet. The raw/minimum/maximum water tank level values should be a figure on the order of 500 (out of a maximum 65,535) with no sensor attached.

Now you can power the unit down and temporarily connect the sensor to CON1, with the red lead to the + terminal and the black lead to the – terminal.

Power the unit back up and check the raw data that was logged to ThinkSpeak.com.

With the sensor in open air (ie, not underwater), our prototype gave a reading of just over 20,000. This should increase if the sensor is put at the bottom of a bucket of water.

Note that calculations suggest the reading for a sensor current of 4mA should be around 12,700 but the sensor could draw more than 4mA even at atmospheric pressure and there is also an error due to the input offset voltage of IC1, so the initial reading could be anywhere in the range of about 10,000 to 22,000.

Assuming you're getting a sensible reading, power the unit down and you are ready for the final steps.

Final assembly

Now to mount the unit in a waterproof box for installation outdoors.

We used an IP65 sealed case with clear lid (available from Altronics or Jaycar). It measured 170 x 120 x 55mm which gave us enough room to fit all the parts, including the battery and charger board.

We glued the solar panels to the inside of the clear lid, which had just enough space.

We recommend using neutral cure silicone sealant to do this. You can also use the same sealant to hold the Arduino PCB, battery and charger module in place.

See the internal shots of our prototype for an idea of how you can arrange them.

Remember to leave room to plug in the USB cable that goes between the charger board and the Arduino (and so that you can still connect the Arduino to your PC in future, should that be necessary).

The two main holes needed to be drilled are a 19mm hole for the cable gland and a 6.5mm hole for the SMA WiFi antenna socket. We placed these on either side of the internal rib at the end of the case, making sure there would sufficient space around the cable gland hole to allow us to fit the internal nut.

Remember we mentioned earlier that the barometric pressure and humidity sensors will need access to the outside air to give proper readings.

We don't want rain or other nasties to get into the box but we can't have it completely sealed either.

So we drilled four 3mm holes in the bottom of the case, near the middle, and glued a piece of open-cell foam over them.

That will allow outside air to mix with the air inside the case while preventing moisture, dirt and dust from getting in.

The box will be orientated so that rainwater will not block the holes in the final installation (ie, with the bottom facing down).

Solar panel wiring

Once the silicone holding the solar panels onto the inside of the lid had cured, we soldered the anodes of schottky diodes D1 and D2 directly onto the + output pads of the two panels and soldered the cathodes together.

The 2.0mm JST cable was then soldered with the positive lead to the joined cathodes of D1 & D2 and the negative lead to the – output pad on one panel, which was then connected to the – output on the other panel with a length of hookup wire (see the photo opposite).

We didn't apply any insulation to the diodes nor anchor them (except via soldered joints) but if you are at all concerned, a thin bead of silicone sealant will both hold them in position and also insulate them.

Be careful with the polarity of the JST cable because unfortunately there is no standard for which wire is red and which is black.

You need to plug it into the solar input on the charger temporarily to check which wire goes to the + input and make sure that the wire on that side goes to the diode cathodes (we try to supply wires with the correct colour coding with our modules but it isn't guaranteed).

If you haven't already fitted the cable gland and antenna socket (assuming you're using one), do so now, then feed the sensor wire through the gland and attach it to the terminal block. Do up the gland tightly to make sure no water can get in and screw the antenna onto the socket.

You can then plug the battery into the charger board and the antenna cable onto the Arduino board.

Fit the Arduino shield, connect the USB cable which carries power from the charger and plug the lead from the solar panels into the input on the solar board.

You can then fit the lid to the case using the supplied screws and waterproof gasket, which is inserted all around the channel in the lid before it is screwed into place.

Drop the sensor into the water tank and find a location to mount the main unit where it will receive as much sun during the day as possible, especially in winter.

Unfortunately, many water tanks are right next to a building, making this difficult. You may need to mount the unit on a fence post nearby.

If the unit stops transmitting data in the early morning in winter, you'll know the solar panels aren't getting enough sun to keep the battery charger and more (or larger) panels, or a mains power supply, will be required to keep it going.

Calibration

This is essentially automatic as the unit keeps track of the highest and lowest readings and uses these as the 100% and 0% levels.

That means to calibrate the unit, once it's powered up and running, the tank needs to be filled. If it's a rainwater tank, you could fill it with a hose, or just wait for a good storm!

It checks the last eight readings and if the minimum of all those readings is higher than the maximum value that's stored in EEPROM, the stored maximum value is updated. This prevents a brief glitch from affecting the maximum value.

So basically, once the tank is full, that should be recognised as the 100% level after an hour or so. The same is true (in reverse) for determining the minimum level.

But if you powered the unit up for a while with the sensor attached, before it was put into the tank, that should have given the unit time to ascertain the minimum level anyway.

So it might be a good idea to leave the unit running for an hour or two before dropping the sensor into the tank, just to be sure.

The unit ignores readings with raw values below 5000 for setting the minimum level so that if the sensor is disconnected, it won't cause the minimum reading to become incorrect.

If you ever need to force the unit to recalibrate, you can run a wire between pin D8 (ESP8266 pin 15) and 3.3V and then press the reset button. That will force it to forget the stored minimum and maximum values and calculate them again.

You could just let this happen naturally, as the tank empties and fills, or take the sensor out of the tank temporarily (for an hour or two) to re-establish the minimum level, then put it back in and wait for the tank to fill (yes, it will rain eventually!) so it can re-measure the maximum value.

The minimum and maximum values are then used to determine the percentage figure which is logged to your channel.

The raw values are always logged, so you can re-calculate the level later if you have more accurate minimum and maximum readings on hand. SC

Hands-on review . . .

by Leo Simpson

NAVMAN DRIVE DUO GPS Satnav + Dashcam

Given that many cars these days already have built-in satellite navigation, why would you want to install a separate satnav? There are several good reasons, including accurate speed display and more up-to-date maps (free!) – but the main reason with this unit is that it also provides a very good dash camera recorder with features like speed limit and speed camera alerts.

Anyone who has used a satnav in their car probably has a love/hate relationship with it.

They are so good when they guide you to your destination without problems but they can be extremely frustrating when they don't.

These days many new cars come with satnav as a standard feature but virtually all OEM car satnavs have two major drawbacks.

First, map updates are infrequent and two, they usually cost a lot of money after the first couple of years of ownership.

And even if you have just purchased a brand new car, as I have recently, its maps are likely to be one or two years out of date and may not be updated for another year or so.

This is especially annoying when most after-market satnavs now come with free life-time updates. The Navman Drive Duo unit reviewed here comes with free monthly life-time updates.

Secondly, the in-built car satnav does not display your current speed, as measured by GPS or the on-board diagnostics (OBD) system.

This is probably a consequence of the Australian Design Rules (ADR) which means that car speedos can be optimistic, ie, they can show a speed reading which is higher than the actual speed and often the discrepancy can be quite large. For example, at an actual speed of 100km/h, the indicated speed

The two modes of the Navman Drive Duo are shown here and below left, in similar locations on the Warringah Freeway approaching the Sydney Harbour Bridge. Above is the dashcam mode – regrettably, the printing processes do not give it justice because the closest the cars' number plates are quite legible. At left is the Satnav mode, showing the direction it wants you to take.

could be 110km/h or even higher.

This is ridiculous and unnecessary, especially when car odometers are usually quite accurate. (In fact, if you install an OBD-based head-up display or a OBD-to Bluetooth dongle linked to your smart-phone, you can have actual speed – so the car can do it!

This assumes your tires are at the right pressure, that they're not worn, that you haven't changed them to a different size and so on.

(See our September 2013 article on Head-up Displays at www.siliconchip.com.au/Article/4391).

These days most drivers want to travel as close to the speed limit as possible, especially when they are on an expressway and want to use their cruise control. This is desirable because you don't want to impede the traffic flow or cause irritation to following drivers who will otherwise pull out to overtake.

Apart from the advantage of actual speed indication, an after-market satnav will also provide an indication of the posted speed limit and give a warning when you exceed that limit. Most inbuilt car satnavs don't do this.

Avoiding just one speeding fine can easily save double the price of the unit under review.

Just on the pros & cons of in-vehicle versus after-market satnavs, Google maps is a very good navigation system. You can set it up on your smart phone while you are still having breakfast and then when you get into your vehicle it links to your phone by Bluetooth, and in some vehicles you will get the satnav display on the mains screen – really good.

Of course, with an app overlay, Google can also give you the extra stuff such as live traffic warnings, speed limits, speed cameras and so on. Mind you, you do need a smart phone and a mobile data plan.

Still, most drivers will just make do with their car's inbuilt satnav rather than go to the bother of having the distraction of an extra unit on the windscreen or dashboard.

After all, it can be difficult to find a suitable place to install it and it has to have a USB or 12V cigarette lighter cable for the power connection.

But at the same time, many drivers now realise the advantages of a dashcam, in the event of a frontal collision or other accident in front of the car. It could provide crucial information in the event of an insurance claim or a possible charge of traffic rules violation. And having a dashcam means you do need it installed somewhere on the windscreen. That being the case, there is a strong argument to installing a combination satnav (with free updates and actual speed indication) and dashcam and this Navman unit is a great example.

The Navman Drive Duo unit has a 5-inch screen, which I found quite adequate, especially given the clarity of the display. There is another model, the Drive Duo SUV, which has a 6-inch screen – but this sells for around $100 more than the Drive Duo's $249.00 (rrp).

Incidentally, we note that several merchants on ebay offer the Drive Duo – at prices up to $80 **more** than available direct from Navman: just goes to prove that buying on line is not always the bargain you might think!

The biggest negative I found was that, like most after-market sat navs, that the display was not particularly good in either very bright sunlight,

Features

5-inch LCD Screen

Wide angle, *f*/2.0 1080P lens (full HD) – mounted on gimbal to aim where you want it to go

Lane Departure Warning System – LDWS activated at >60km/h when you deviate away from your lane. This not only use the "white lines" as in many other brands but cleverly monitors the horizon for changes as well.

Built-in 3-Axis G-Shock Sensor measures impact and automatically locks the recorded video footage, impact location and date/time into an events vault.

Bluetooth handsfree.

Voice activated.

Following too close Alert – FCWS This alert warns you when you are travelling too close to the vehicle in front, reminding you to allow more space to brake.

Speed limit alerts.

Speed/Traffic Light Camera alerts.

Free lifetime map updates.

GPS Tracking, Photo Geotagging. Records the direction, location and speed travelling as well as capture still images so you can save and download EXIF data to assist in insurance claims.

Still photo mode.

Headlight/low light alert.

Manual recording when you feel threatened eg, road rage or any other reason.

Uses standard microSD cards.

These two images from the Navman Drive Duo really test any camera – but the Navman passed with flying colours! The above shot is looking directly into the sun at 7am . . .

. . . while the night-time shot easily caters for different light levels, car headlights and so on. Not too many digital cameras would handle a scene like this as well!

or worse, when the Sun was actually shining on it through a side window or sunroof. Wearing sunglasses can also be problematic.

When you take it out of the box, a small feature is immediately apparent: its suction cap mounting bracket is quite compact and not some monstrosity which is difficult to install on a steeply raked windscreen without creating a major obstruction to the driver's view.

So that's a big tick for Navman.

Then when you go into the installation procedure (in the Drive Recorder settings), you will find that it has on-screen indicators to help you set up the unit to properly cover the road ahead.

Of course, you need to connect power to the unit and this is where most cars are lacking: a suitable connection close at hand.

Why don't cars have one or more 12V and USB outlets right on the dashboard, say close to or within the speedo binnacle?

I experimented with positioning the review unit just to the left of the speedo binnacle, so that it caused relatively little obstruction and was in easy reach for the touchscreen.

Some of the pics in this review were taken with it in this position. Later I moved it to a more central position on the dashboard which gave slightly less blocking of my vision but was still within easy reach for the touchscreen.

The Navman also has voice control (similar to the inbuilt unit in many current model cars) – for many functions, you don't need to operate it via the touchscreen.

And that brings up another interesting feature. When I pressed the voice control button on the touch screen, the Drive Duo told me to say something from a displayed list of commands.

At top of the list was "home" and I duly said that, knowing full well that I had not yet stored my home location. After all, in most satnavs, whether they are original equipment or after-market, you have to store your home location.

In fact, it might a good idea not to store your home location, just in the case your car is stolen and a thief decides on an impromptu after-hours visit. Many people delete their home address and put in an address around the corner or a block away.

But the Navman unit was way ahead of me and based on a week or so of use, it had worked out my home location. Hmm, that could be a problem. Anyway, it then proceeded to navigate me home. Later, I found that it had also stored addresses such as the SILICON CHIP premises and others that I had recently visited.

This is a degree of cleverness that some people will appreciate but others may not! You might want to delete automatically stored addresses from time to time.

Other notable features of the Navman Drive Duo satnav are Landmark Guidance which draws attention to petrol stations, churches, cinemas and other points of interest to help guide you, as well as realistic junction views with signage, spoken safety alerts and Trip Planner which allows you to set several stops on your journey.

And there is also Handsfree Bluetooth phone operation – very handy if your car does not have this feature or is problematic when registering your phone.

One thing you must do with many satnavs is to cancel the journey once you have completed it.

Otherwise, your satnav will think you have gone batty and will persist in trying to direct you back to where it thinks you should be. This comment applies to both inbuilt car satnavs and aftermarket units like this Navman Drive Duo.

I should also note that the in-built GPS receiver seems to be quite sensitive and quickly acquires the satellites, compared with other GPS satnavs I have used in the past.

Another favourable comparison with other satnavs I have used in the past involves map updates.

In general, the maps in the Drive Duo appeared to be quite up-to-date

Looking at the rear of the Navman Drive Duo and its *f*/2.0, 1080P wide angle camera. Not immediately obvious here is the fact that the camera lens can swivel to take into account the angle of the windscreen and the direction you want the camera to face.

Speedo reading versus GPS speed reading: why the difference?

In this article, we referred to the particular Australian Design Rules which specify the performance of a vehicle's speedometer. The relevant rule is ADR14, which in turn is based on a United Nations specification so that (theoretically) speedometers the world over will read the same way.

The rules used to say that a speedo had to be accurate to within plus or minus 10% when the vehicle was travelling at 40km/h or over. So at 100km/h a speedo could read anywhere from 90 to 110km/h. Many people believe this to still be the case.

However, ADR14 was changed in 2006 to state that a speedo must not indicate a speed less than the vehicle's true speed but could indicate a speed as much as 10% +4km/h over its true speed.

So if the post-2006 vehicle is travelling at a true speed of 100km/h, the speedo could read anywhere from 100km/h to 114km/h. You'd never cop a speeding fine at that rate!

GPS-derived speeds (as in an after-market satnav) are often presumed to be very accurate – and in fact, most of the time they are. However, there are many reasons why they too may be in error – above **or below** true speed – mainly due to insufficient satellite data at that time (inner city "canyoning" effect or heavy vegetation are two well-known factors).

So you cannot absolutely rely on a GPS-indicated speed to avoid getting a love letter from the authorities!

One further note: in many vehicle tests, has been widely established that the more expensive a vehicle is, the more likely its speedo will indicate closer to the true vehicle speed – ie, it's more accurate (although there are many exceptions!).

And it's also true that most heavy vehicles' speedometers are much more accurate than ADR14 would require – most truckies will tell you that their speedo and their after-market GPS usually read within 1km/h or so.

That could also be why when you're travelling at an indicated speed of 100km/h, all you can see in your rear-view mirror is the grille of a semi-trailer wanting you to speed up or get out of the way!

and that is commendable.

However, I cannot make the same comment about speed limits. While it was pretty good in the suburbs of Sydney where I did most of my driving during the period of this review, it was often years out of date in regional areas west of the Blue Mountains, such as in Bathurst and Oberon.

And also in common with other satnavs, this unit could be confused and show speed limits on adjacent roads or over-passes (and warn about non-existent "safety cameras" when driving on freeways).

I assume this is linked to the overall dimensional accuracy of the GPS itself (currently about 4m maximum horizontally but much worse vertically – eg, when you're driving under a freeway overpass).

In general though, the Drive Duo performs well as a satnav and is clearly ahead of many OEM in-built satnavs in most recent model cars.

Battery backup

The Drive Duo has an internal lithium ion battery which will maintain settings when, for example, moving between your car and computer, or into another car.

Prior to use for the first time, it must be plugged into a power source for at least eight hours to fully charge the internal battery.

However, it is not intended for the sole source of power for an extended period. Don't expect it to last too long, – we didn't time the battery life and it's not mentioned in the documentation but we would reckon if it's typical of most satnavs you'd measure the life in minutes, not hours. The Drive Duo is definitely designed as a plug-in device!

The dashcam

All of the above is combined with an HD 1080P dash camera and ADAS (Advanced Driver Assistance Systems) which provides an audible lane departure alert and spoken front collision alert.

I must say I was surprised at the inclusion of front collision alert since the Navman Drive Duo does not have the advantage of a frontal radar system that is included on cars with radar cruise control and autonomous braking.

On the Drive Duo, both the lane departure and front collision alerts depend on digital process of the camera images while the lane departure warning also used accelerometer data. And this feature only works at speeds above 60km/h.

Another still, captured from the Navman Drive Duo vision. You can not only read the number plate of the car in front but in the moving picture, the Range Rover on the right AND the car on the other side of the traffic lights!

How do they work in practice?

Not particularly well! I could not activate the lane departure alert at any speed even though I deliberately crossed over road lane markings. At the same time, my car's in-built lane departure alert was shrieking madly, so there was little doubt about my driving behaviour.

The front collision alert was more problematic. It does work but I feel that most drivers will turn it off since it is over-protective in normal city traffic; perhaps it is more useful on freeways and the open road.

Being a somewhat intolerant driver, I found that the voice warning quickly became really irritating as it would trigger when stopped at a roundabout and then triggered by cars going round it.

It could triggered by cars turning left or as I turned the corner.

After one such warning "You are driving too close to the car in front. Please increase your distance!" I shouted back "No I'm not, there is no #&@@% car in front of me!"

It didn't answer.

Day vision

It is a few years since I have used a dash cam (on my previous car) and this HD camera really does represent a big step forward, performing very well in most lighting conditions.

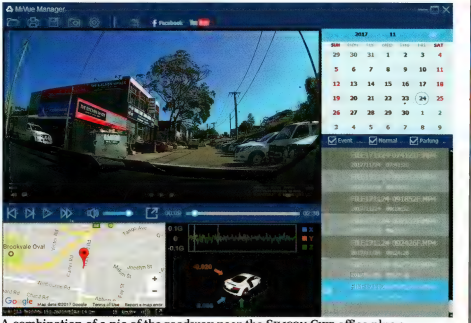
For example, driving into the Sun is a severe test of any dash cam but the Drive Duo comes up trumps; better than the driver, I should say. We feature a screen grab of this performance in this review.

And it must be said that the dash cam will unerringly record events that you may simply not have registered, as you glanced at the dashboard, talked to a companion or looked away from the road ahead.

In the event of an accident, the dash cam records the event as it unfolds, even though you may not at first realise the potential disaster as it develops.

During the couple of months of driving with this Drive Duo, I have been fortunate enough not to have any really close calls but reviewing the footage after a few days' driving, it is surprising just how many other drivers have done "stupid stuff" which thankfully has not had any bad results. Me? Of course not!

There is mention made in Navman promotional material (and online) of the ability to add an optional (~$140) rear-view camera, the Navman A20.



A combination of a pic of the roadway near the Silicon Chip office plus a Google map showing the photo location, the g forces on the car at the time (I was driving very slowly!) in both graph and instantaneous format, a calendar showing when the pic was taken and a list of the relevant files. Again, printing processes really don't do the photo justice: it's superb!

While this would be a really worthwhile addition, there is only the briefest of mentions in the instructions (ie, don't plug the power source into the rear dash cam connector!) so I cannot comment further.

Night vision

Most dash cams do not perform well at night. The extreme contrast between bright headlights, street lights and surrounding darkness is simply too much for them to cope with.

But the Navman Drive Duo works surprisingly well at night – it's good enough to make number plates of cars quite readable, so I was impressed with that.

But it does come unstuck when it is raining. It is OK if the windscreen wipers can clear the screen in light drizzle but down-pours will be too much. To be fair, that tends to apply with human vision too.

Note that the dash cam must be able to "see" through a wiped area of the windscreen.

If that condition cannot be met (eg, if it is mounted outside the wiper blade's arc), you can forget recording anything useful during night-time driving or in the rain.

This impressive day and night performance is enabled by Navman's WDR (Wide Dynamic Range) technology which is applied for recording images smoothly under the condition of severe light contrast.

WDR allows an imaging system to correct for the intense back light surrounding a subject (eg, driving into the Sun) and thus enhances the ability to distinguish features and shapes on the subject.

Videos taken under these conditions still show significant details in the shadows.

Its performance is significantly better than any "stand alone" dash cam I have ever experienced, especially those in the lower price range.

And having one combined unit (instead of individuals) mounted on the windscreen is definitely a bonus.

The lens, an *f*/2.0 1080P (full HD) wide angle type, is mounted on a gimbal so it can be adjusted to take into account windscreen rake.

In fact, there is specific detail in the setup procedure to help you achieve this.

OK, so the Navman Drive Duo HD camera is undoubtedly an impressive unit.

The videos are recorded in 3-minute blocks as MP4 files accompanied by NMEA files which record all the GPS-derived info such as location coordinates, speed, time, compass heading, 3-axis accelerometer forces (accelera-

How do satnavs provide traffic updates?

Readers may be wondering how satnavs actually provide the traffic update information that flashes up on the screen.

After all, they do not have a satellite link apart from the GPS function and that certainly does not provide up-to-minute traffic information.

Nor do they have an in-built 3G or 4G SIM card and a data plan. So how they do it?

In Australia, traffic information is broadcast across the major metropolitan areas of all states and territories and some of the larger regional cities in Queensland, NSW and Victoria by SUNA traffic: www.sunatraffic.com.au

The information is digitally encoded and broadcast by FM broadcast stations using RDS (Radio Data System), which is also employed to provide station identification, time and program information.

The traffic information embedded in the RDS signal is received and decoded by the satnav.

In a typical Australian city there are hundreds of traffic reports (accidents and congestion etc) and these may or may not be displayed on your satnav, depending on your location and route.

Not only does SUNA provide traffic reports but it also enables the satnav to calculate the length of a journey and ETA, based on current traffic conditions.

One point I should make and that is even though the traffic info is broadcast via some FM stations using RDS, this Navman unit does not depend on your car's radio for this data. It uses the supplied cigarette lighter power cable as the antenna. If you use another cable or a USB cable to power the unit, it may not pick up the traffic info.

tion, braking and cornering) and so on.

You can play and view the recordings on the Navman Drive Duo or the MP4 files can be viewed on your computer with any media player, such as VLC but you may not have sound playback without installing extra codecs.

Mivue Manager software

Alternatively, you can use Mivue Manager (which has to be installed on your computer) to view the recordings and this is really quite impressive, as shown in some of the screen grabs included in this article.

Either way, the micro SD card must be removed from the recording slot on the Navman and moved to the data access slot

Two modes are available; one showing the video with sound, together with all the GPS data listed above. The alternative also shows the video with sound but is accompanied by the Google map for the route you took – but note that your computer must be linked to the internet to access Google maps.

In principle, Mivue Manager is a great feature but we found it buggy in practice as it would not display the video with the picture occupying the designated screen area; it would only show in small area at the top left hand corner – frustrating!

We were unable to solve this bug at the time of writing. Our Mivue screen grabs (working around this bug) are brought to you by the magic of PhotoShop!

Conclusion

This may sound like a fairly mixed review and while it is "NYP" (not yet perfect), the Navman Drive Duo HD is a big advance in technology.

Its satnav functions work well and the HD camera is very impressive; a most worthwhile inclusion for anyone concerned with recording daily drives, just in case there is an accident. . .

Price and availability

We mentioned earlier that the Navman Drive Duo has a recommended retail price of $279.00 but at the time of writing (early December), there was a $30 cashback being offered (due to expire mid February).

That's all spelled out on the Navman website (www.navman.com.au – search for Drive Duo).

But we also made the point, worth repeating, that buying from some auction sites may not be quite the bargain you think it is – we've seen this particular Navman being offered online for more than $330! SC

Wagner
ELECTRONICS SUPER STORE
OVER 40 THOUSAND PRODUCTS ONLINE 1500+ PAGE CATALOGUE AUSTRALIA WIDE SHIPPING

AUDIO/VISUAL ACCESSORIES
SPEAKERS / PRO AUDIO
ELECTRONIC COMPONENTS
DATA & ELECTRICAL
TOOLS & TEST EQUIPMENT
BATTERIES & MORE!

BUY ONLINE AT WAGNERONLINE.COM.AU

VISIT OUR SYDNEY STORE
84-90 PARRAMATTA ROAD, SUMMER HILL, NSW 2130
02 9798 9233

An easy-to-build 6-element VHF Yagi for

Great Digital TV Reception

Do you watch VHF TV? Do you have problems with drop-outs of your favourite stations? Is the picture often affected by intermittent pixellation accompanied by "spitting" sounds? Does your TV give a "no signal" message in periods of wet weather? If you answered "Yes" to any of these questions, the chances are that your TV antenna is no longer suitable for the stations you are hoping to receive.

By LEO SIMPSON and ROSS TESTER

This screen shot, which we found on YouTube, ably demonstrates what can happen when you use an old (or even a new!) UHF/VHF antenna on a VHF TV signal. It's almost certainly caused by breakthrough from UHF LTE phone or data signals "swamping" the VHF signal. The solution, at least in VHF-only capital cities, is to use a VHF-only TV antenna!

Our new 6-element VHF TV antenna is simple to build, from easily-obtainable aluminium tubing . . . but gives a great account of itself in metropolitan areas where VHF TV broadcasts predominate. It should also be adaptable for the relatively few country areas using VHF (except perhaps "fringe" areas). If you still have an old band II/III VHF antenna or worse, a "combi" VHF/UHF antenna, this design should help eliminate interference from other services now using the old TV frequencies. Notice that it has horizontal polarisation, to suit the majority of VHF transmissions (eg, all state capitals).

Perhaps you have not realised that in 2014, along with the switch from analog to digital TV in Australia, all VHF metropolitan TV channels were "restacked" into the higher VHF band, nominally channels 6 to 12 (band III).

Remember being bombarded with TV ads telling you that you had to retune your TV set? Or the scores of little old ladies calling talkback radio saying "my TV doesn't pick up 'Days of Our Lives' any more . . ."

Previous to that you might have been receiving your main TV broadcasts from VHF or UHF channels. Or maybe you were using an old TV antenna which was suitable in the days of analog TV broadcasts but long-term corrosion and different channel allocations have now made those old antennas simply no longer suitable.

If you take a drive around city streets you will often observe that many people are still using a VHF/UHF Yagi array (with very long and very short elements), a log-periodic VHF/UHF array or maybe UHF bow-tie array. Since the digital TV "restack" most of these antennas simply are not suitable in metropolitan areas.

More information on this digital restack topic can be seen in our November 2014 issue, in an article by Allan Hughes (www.siliconchip.com.au/Article/8081).

Now over the last few years, you have probably had your TV do a rescan to receive new channels and it has duly picked up the stations you want, plus the regional stations which are typically broadcast from band 4 UHF translators. In that case, you might say, "It works. Why worry?"

Well, your old antenna probably does work – sort of.

But the fact that the antenna is not cut to suit the restacked VHF channels could explain your occasional reception problems.

Another factor to be considered is that the old UHF TV channels that you happily used have now been allocated to 4G mobile phone and data use and that can mean that your TV is now being subjected to 4G LTE interference.

This will only get worse – probably much worse – in the future as more and more phone/data services are packed into the old UHF TV band.

Overall, if your TV antenna is more than a few years old, there is a fair chance that it is not delivering the optimum signal to your TV set.

And while digital TV reception is not subject to the many problems of the old analog TV broadcasts, such as ghosting, noise, aircraft flutter and is more tolerant of varying signals, once the signal level drops below the "digital cliff" you reach the point where the picture starts to pixellate and then drops out altogether, leaving you with that annoyingly cryptic "no signal" message on screen.

That can be really frustrating at the crucial points in your favourite TV series or sports broadcast.

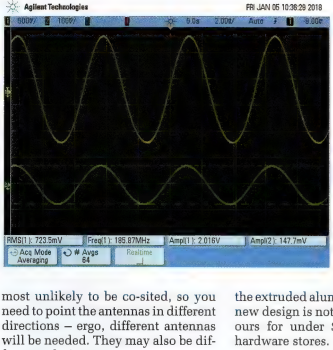
The "digital cliff", by the way, refers to the fact that with digital signals there is very little between a great picture and no picture. It's either there . . . or it's not, as if the signal simply "falls off a cliff".

So you probably need a new antenna

Do you buy or build? If you are going to buy a new antenna do not buy one from an overseas source. They are unlikely to be cut to suit Australian VHF Digital TV broadcasts.

Second point, **do not** buy a VHF/UHF array. You don't need it and it is likely to feed unwanted 4G interference to your set, as can be seen opposite.

Even if you want to receive both VHF and UHF, the transmitters are



How we measured the antenna's gain

Elsewhere in this article we mention that this antenna has a gain of 10dBd; that's +10dB with respect to a standard dipole. But measuring the gain of any antenna is not a simple process and ideally you need to do it in an open paddock with no large objects, buildings or hills nearby. We made do with the parking area behind our building.

We used a Hewlett-Packard 8654B RF Signal Generator which covers the range 10MHz to 520MHz and can deliver 1V into a 50Ω load. We matched this to the 75Ω impedance of standard dipole which was connected via 75Ω coax cable.

The scope grab at left demonstrates a test in progress. The yellow trace is the output from the RF generator while the green trace is signal received under test. Note that we have applied signal averaging to remove noise. We had to do repetitive tests at different frequencies (for channels 6 to 12). In each case we used standard dipoles for the transmitter and the receiver and the receive dipole measurement was then compared with the same signal picked up by the 6-element antenna under the test conditions.

most unlikely to be co-sited, so you need to point the antennas in different directions – ergo, different antennas will be needed. They may also be different polarisation.

If you are going to buy a new antenna or have it installed, make sure it comes from a reputable Australian manufacturer.

Make no mistake, these Australian companies make well-engineered antennas which will give many years of service and some of their antennas also incorporate 4G LTE filtering as well.

Be warned, though, there is a lot of rubbish (dare we say cons?) around – particularly online. (See the physics-defying model on page 43!).

But you can save a significant amount of money by building your own.

How much much money? We reckon you can build the antenna described here for less than $65. Depending on where you buy a new antenna, you could save more than half the price.

What about recycling your old antenna?

A number of readers have suggested this project and one of their cited reasons has been to recycle the aluminium tubing from their old antenna.

If you look at the dimensions of the elements of this 6-element Yagi design, you *might* be able to salvage some of the longer elements from an old low-band VHF antenna. But we don't recommend it.

Those old elements are likely to be heavily corroded rolled section aluminium and not worth the trouble and work in cleaning them up. The cost of the extruded aluminium tubing in our new design is not high; we purchased ours for under $40 from Bunnings hardware stores.

Why bother with that old tatty antenna? Stick it out for recycling at your next council clean-up.

By the way, before you contemplate starting this antenna project, make sure that you are in prime reception area for VHF channels 6 to 12.

You can do that by going to this website – http://myswitch.digitalready.gov.au/ and feeding in the details of your location.

However, this website is not infallible. By far the best approach is to simply to walk around your neighbourhood and see what the majority of antennas are.

If you note that the majority are UHF (ie, short elements) pointed away from your city's primary transmission location, it's a reasonable bet that there is little or no VHF signal in your location.

After all, there is no point in building a VHF Yagi if your main reception comes from a regional (UHF) translator, as it may do even if you live in the heart of an Australian city such as Sydney.

For example, in hilly areas such as Sydney's Northern Beaches, many TV antennas are pointed towards the Bouddi translator on the Central Coast, perhaps 40km away.

This is despite the fact that they might be only 10km or so from the main VHF transmitters at Artarmon – but there's a dirty great big hill in the way!

Similarly in the Southern suburbs – many viewers get their pictures from one of the even more distant Illawarra translators.

And what about the recent SILICON CHIP DAB+ antenna?

Some readers will recall that we published a 5-element DAB+ antenna in the November 2015 issue (www.siliconchip.com.au/Article/9394).

And, given its ease of construction, a few readers suggested that we simply rescale that design to produce this VHF antenna.

This turns out to be impractical, mainly because the VHF coverage of this new antenna is considerably wider than that for the DAB channels (which sit in a narrow band smack bang in the middle of the TV channels).

Secondly, this antenna is intended for horizontal polarisation while the DAB+ antenna is a vertically polarised design with the mast fixing point behind the reflector.

And because we are covering a wider bandwidth we decided to go for a 6-element design which should give more gain over the frequencies of interest and a little less for DAB+ reception.

By the way, some VHF TV antennas are stated as being suitable for DAB+ reception as well as TV.

That is partly true, but if you are using a horizontally polarised VHF TV antenna for TV reception, its pickup of DAB+ broadcasts will be largely incidental. Having said that, such reception may be quite adequate in your area.

Antenna gain

A 6-element Yagi antenna like this

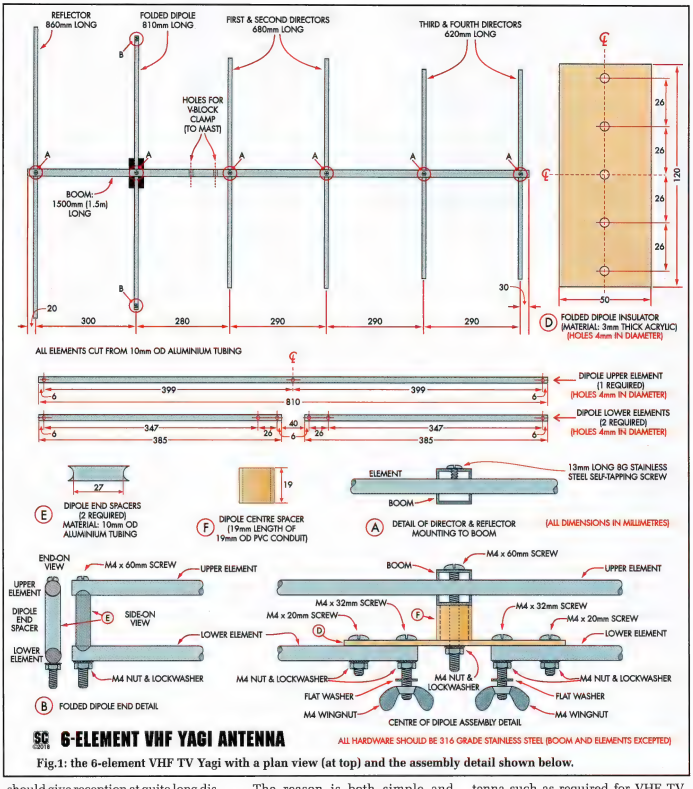


Fig.1: the 6-element VHF TV Yagi with a plan view (at top) and the assembly detail shown below.

should give reception at quite long distances from the transmitter, perhaps 100km or more. However, we have not tested this aspect. We can vouch for the gain figure of around 10dB (as detailed on page 38).

You may also wonder "why six elements?" when the DAB+ antenna had five – indeed, you often see antennas with fewer elements or more.

The reason is both simple and complicated. The simple part is, the more elements the higher gain, so you should pick up more signal.

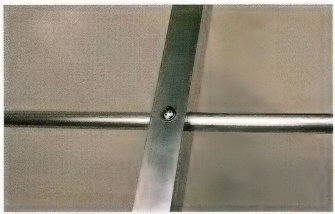
The complicated part is that you soon run into "the law of diminishing returns" where adding more elements doesn't really justify either the cost nor the increased size.

Six elements, for a wide-band antenna such as required for VHF TV, appears to be the "sweet spot".

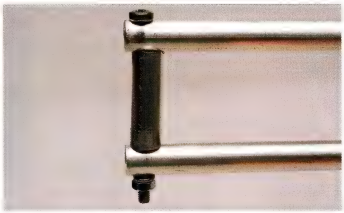
Tools you will need

Most enthusiasts will have most of the tools needed for this project. You will need a hacksaw, electric drill and a vise. It would also help if you have a drill press but you can do without this.

Apart from an antenna clamp (U-



The reflector and director elements are attached directly to the boom using self-tapping screws. Ideally, all screws, nuts and washers should be 316-grade stainless steel to minimise corrosion.



The ends of the folded dipole are fabricated using 39mm lengths of aluminium tubing shaped to mate with the upper and lower pieces. They are held together with 50mm long machine screws, nuts and split washers.

bolt and V-block), no special hardware or fittings are required.

Tube cutter

A tube cutter is a very handy tool in an antenna project such as this. You end up with smooth square cuts with no swarf. We used a Bunnings product, the Haron Model STC330N. When using this cutter, it is important not to rush the job.

Mark the position of the cut on the tube with an HB pencil and then position the blade of the cutter precisely on the mark, with the tube sitting between the rollers. Apply very light pressure with the knob of the cutter and then measure from the end of the tube to the blade of the cutter, to make sure you are cutting to the exact length you want (to be sure, to be sure!)

If you have not used one of these cutters before, do a couple of practice cuts on scrap of aluminium tube or plastic conduit, just to get the feel of the whole procedure.

You are also likely to find that because the tube is very smooth and quite small in diameter, it is hard to get a grip on it as the cut deepens. Gripping the tube with a rubber kitchen glove makes it a lot easier.

Buying the aluminium

For convenience we purchased the 10mm round aluminium tubing and 19mm square aluminium tube from the local Bunnings warehouse. They stock the 19mm square tube in 3-metre lengths and the 10mm tubing in 1-metre lengths.

So we purchased seven 1-metre lengths of the 10mm tube and one 3-metre length of the 19mm square tube. Total cost: just under $40.

You might be able to purchase your aluminium from a nearby metal supplier and in that case, they might cut it to the various lengths you will need (perhaps for a small extra charge?).

One drawback of buying tube from Bunnings is that every item you purchase has an adhesive label attached which can be quite difficult to remove. While the label won't interfere with reception, simply for appearance sake you will need to remove all traces of the adhesive and that can be done with kerosene or eucalyptus oil.

Screws & nuts

After a few years' exposure to the elements, many antennas are in a poor state. Aluminium does not "rust" but it does oxidise and its surface becomes very powdery, particularly in seaside areas or in metropolitan areas where there is a lot of industrial fallout.

Corrosion will also be a lot worse if you don't use the right screws and nuts. We strongly recommend the use of stainless steel screws, nuts and washers throughout, whether for machine screws or self-tappers. They do cost more but they last indefinitely.

Some readers may wonder about the grade of stainless steel required. We recommend AS316 for best corrosion resistance; it is better than the inferior AS304, particularly in seaside environments.

You may find some of the required stainless steel screws are available from Bunnings – however, make sure they are AS316 (the packet will be clearly labelled). Most will be also available from ships' chandlers (almost invariably AS316) or specialist hardware or engineering suppliers. We purchased our stainless steel parts from Bomond Trading Co, in Brookvale, in Sydney.

Don't, on any account, use brass screws. When used to attach aluminium elements these will corrode away almost before your eyes. Nor do we recommend galvanised, bright zinc or cadmium-plated and passivated steel screws (with a gold appearance – they're rubbish!). In seaside areas, all of these can be visibly corroded with just a few days' exposure.

In rural areas, away from the sea or city pollution, you can probably get away with galvanised screws but the antenna will last longer if you paint it – including all the screws.

Starting work

Constructing this antenna is quite straightforward. If you have all the materials available you can probably do it in a couple of afternoons.

Fig.1 shows all the details of the 6-element antenna. It shows the dimensions of all the elements and the various hardware bits you will have to make to assemble the antenna. At top is a plan view showing the lengths of all six elements and their spacing along the boom. Note that the spacing between the elements varies.

Before you start, make sure you have obtained all the aluminium and hardware listed in the Parts List. You will be frustrated if you get half-way through and find you can't progress further because you lack screws or some other item. Get 'em all before you start.

You need to cut the 19mm square tube (the boom) to length and then

mark it for drilling and this is where it is quite easy to make mistakes. Double-check everything before you cut or drill!

If you are experienced in metalwork and have access to a set of vee-blocks and a drill press, you could substitute 25mm diameter stainless steel tubing which is readily available but quite expensive and quite difficult to cut and drill.

Do not use nickel plated tubing – it will rust quickly. Nor should you use stainless steel tubing sold for wardrobe hangers. It is likely to be AS304 rather than the specified AS-316 and will corrode in seaside areas.

Centre-punch the boom for all holes prior to drilling. The boom is 1500mm long – see the plan diagram on Fig.1. Mark the hole centre position for the reflector element first, 20mm from one end of the boom, and then work your way along.

If you have a drill press which lets you drill all the element holes square through the boom you are fortunate. If not, mark the hole centre positions on both sides of the boom and drill from both sides. If you don't get the element holes lined up properly, you will have the elements skew-whiff, and that may degrade performance.

A few words of advice on drilling is appropriate here. Drilling in thin wall aluminium tubing can be a problem and many people tend to end up with holes that are more triangular than round. The way around this problem is to drill all the large holes (ie, all 10mm holes) under size and then ream them out to the correct size using a tapered reamer.

Don't drill the larger diameters with too high a speed otherwise there may again be a tendency to produce "triangular" holes. If you have a bench drill which allows you to set slower drilling speeds, so much the better.

Either way, it is best to drill the element holes to 10mm and then slightly increase each hole with a tapered reamer so that each element is held firmly in the boom.

Reaming larger holes

Be careful when reaming holes out because it is quite easy to get carried away and then end up with holes that are oversize. Use a scrap piece of 10mm tubing to test when the holes specified at 10mm are the correct size.

Each director element and the reflector is held in the boom with a self-tapping screw, as shown in diagram A of Fig.1. Drill a 3mm hole at the centre point of each element but only through one side.

Don't mount the elements on the boom yet because the dipole should be assembled and mounted on the boom first.

You need to keep a mental image of how the finished antenna will appear. If at any time you become confused, take a look at Fig.1 and the photos showing the actual antenna we built.

Making the dipole

The folded dipole is made from five pieces of 10mm aluminium tubing: one 810mm long, two short (385mm) and two tiny end spacers around 34mm long. The detail of its assembly can be seen from the diagram at the bottom of Fig.1. The two short tubes, shown as diagram E on Fig.1, are cut and shaped so that they key in with the top and bottom elements of the dipole.

Again, further detail can be seen in the accompanying photos. The top and bottom pieces of the dipole are held at each end with a 60mm long M4 screw, together with a nut and lock washer.

At the centre, the lower halves of the dipole are terminated on an insulating plate (shown in diagram D of Fig.1). This plate is made of 3mm acrylic (Perspex or Lexan). The dipole halves are each secured to the insulating plate with a 20mm long M4 screw, nut and lock-washer.

Terminals for the dipole are provided with two 32mm long M4 screws, each fitted with a nut and lock-washer plus a wing-nut and flat washer.

The insulating plate is secured to and spaced off the main boom via a 19mm length of 19mm PVC conduit, shown as a "dipole centre spacer" in diagram F of Fig.1.

The top piece of the dipole is secured to the boom with a 60mm long M4 screw, nut and lock-washer.

The details of the dipole insulating plate and fixing to the boom can be seen in the accompanying photos. Note that while we used black Perspex, you could use a piece of polycarbonate if that is what you have on hand. However, note our remarks on painting, later in this article.

By this time the antenna should just about complete. You need to add the antenna clamp, to enable it to be attached to the mast. This must be just behind the first director.

You will also need a 300Ω-to-75Ω balun to match it to 75Ω coax cable. You can purchase this from Jaycar (Cat LT-3028).

Unfortunately, many antenna clamps are sold with a cadmium-plated and passivated finish (which look like a "gold" finish). This is barely adequate for inland areas but rusts quickly in sea air. We may seem to be paranoid about corrosion but since the SILICON CHIP editorial offices are only a kilometre or so from the crashing

Parts List – 6-element VHF TV Antenna

Aluminium

1.5 metres of 19mm square tubing with 1.2mm wall thickness
7 1-metre lengths of 10mm diameter tubing with 1mm wall thickness*

Hardware

1 120 x 40 x 3mm Lexan or Perspex
1 stainless steel or galvanised U-bolt and V-clamp to suit mast
5 8G x 13mm pan head self-tapping screws
3 M4 x 60mm (pan head)
2 M4 x 32mm screws (pan head)
2 M4 x 20mm screws (pan head)
7 M4 nuts
2 M4 wing nuts
7 M4 lock washers
2 M4 flat washers
1 19mm long spacer cut from 19mm electrical conduit or 19mm square aluminium tubing

Miscellaneous (sizes/lengths to suit)

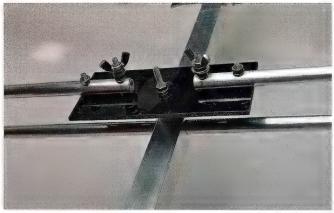
Mast and wall mounts or barge-board mount (hockey stick style)
300Ω to-75Ω in-line balun (Jaycar Cat LT-3028 plus matching F-connector)
Quality 75Ω coax cable to suit (Jaycar WB-2006/9, Hills SSC32 or equivalent)
Black plastic cable ties
Silicone sealant or Delrin plugs

If required as anti-bird strengthening:

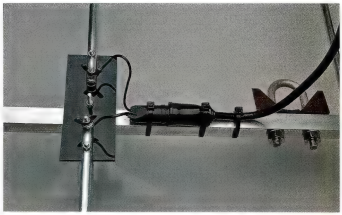
2 1.5m lengths 19mm external use PVC conduit

* Actual length required is approx. 5.2m if being cut into lengths by supplier

Note: all screws, washers and nuts should be AS316-grade stainless steel



The dipole insulator plate has wing nut terminals to connect 300Ω ribbon or a 300Ω-to-75Ω balun. The plate is made from Perspex, Lexan or other acrylic material. The square boom makes mounting easy.



Finally, the 300Ω-to-75Ω balun is secured to the boom using black cable ties. The U-bolt must be sized according to the mast used – we fashioned our own V-block from a piece of scrap angle aluminium as the suppliers didn't stock them.

waves we are very aware of just how quickly metal hardware can rust and corrode.

If you can, buy U-bolts and clamps that are stainless steel, as used for car exhaust systems (or boat fittings), as these will last a lot longer. At minimum, choose hot-dip galvanised.

Be aware that zinc "plated" fittings are not as rust resistant as galvanised types. Zinc-plated fittings have a smooth bright appearance while hot-dip galvanising is unmistakable – it has quite a rough grey appearance.

We also suggest that the ends of all the elements and the boom be stopped up with silicone sealant. This will stop them from whistling in the wind. (Commercial antenna manufacturers tend to squash the ends flat for this reason).

Better still, you can buy Delrin plugs to suit the square aluminium tubing. These look neater.

If you live in an area where corrosion is a problem, it is also a good idea to paint your antenna.

If nothing else, the dipole insulating plate should be painted as acrylic material does deteriorate in sunlight (ie, UV).

We suggest you leave the antenna for a month or so to weather and then paint it with an etch primer. Finish it with an aluminium loaded paint.

Installation

When you have finished your antenna you need to carefully consider its installation. There is no point in going to a lot of trouble making it if you don't install it properly.

Try to install your new antenna well away from existing TV antennas as these can have quite a serious effect on the performance. Similarly, nearby solar panels, metal guttering, electric cabling, metal roofing or sarking (ie, reflective insulation such as Sisalation) can have a bad effect on antenna performance. And don't forget the effect of a hot water tank which may be lurking just beneath the roof tiles.

Combatting the bird menace

Most birds love antennas. You provide them with a lovely vantage point, so they use it. Most birds don't do it any harm but when heavier birds such as kookaburras congregate on it, they can bend the elements.

The two most damaging birds are pelicans and sulphur crested cockatoos. Cockatoos seem to have a particularly mischevous streak – several will bounce on your antenna elements just for fun, to see if they can damage them!

To combat really heavy birds, it is best to provide a strong perch about 750mm above the antenna boom. Then hopefully the birds will land on the perch rather than your antenna.

Mind you, you can easily replace bent elements, since you will have built the antenna in the first place.

An alternative, often seen where large birds are a real problem, is to fit a length of 19mm PVC tube (outside rated for best UV protection) to the outer ends of all elements. This transfers the weight of the bouncing birds over all elements and helps protect them – to some degree.

The PVC tubes can be drilled to 10mm (same as the elements) and slipped over the ends. Silicone sealant will hold them in place but this also tends to break down in sunlight – a stainless steel self tapper could be a better option.

Cockatoos are very destructive and they love chewing antenna cable, baluns and plastic fittings on commercial antennas. You can partly protect the cable if you run it down inside the mast but there is no complete solution.

Finally, install the antenna as high as possible above the roof and guttering. If that is a problem, try to install the antenna so that it is at least a half wavelength away from the nearest metallic object such as guttering or roofing.

This means a distance of about 750mm away from guttering, solar panels etc.

Take care when installing the antenna. Safe working with ladders is particularly important. Take your time and don't take risks. You don't want to end up in hospital with a life-changing injury – a common result of handymen working on ladders.

Line up the antenna so that it is aimed at your designated VHF TV transmitters. Usually they are in the same general location. You can find out more from **http://myswitch.digitalready.gov.au/**

Choosing coax cable

You probably know that there is a wide range of prices for coaxial cable, ranging from cents to dollars per metre. What's the difference and why is it important?

When it comes to coax quality, price is usually a pretty good guide.

Apart from the coax impedance (you

want 75Ω), the main criteria you look for is attenuation, or loss. Unfortunately, all coax is lossy – this means that even if you get the last microvolt of signal from your antenna, depending on the quality of the coax lead, at least some of it will be lost on the trip to your TV receiver. You want to minimise that loss.

Cheaper coax has a solid plastic dielectric, mid-range has an extruded pattern which is mostly air (hence "air-core"); the best domestic coax has "foam core" dielectric (which has minimum loss) and the outer conductor is not only pretty tightly woven (for minimum loss) it also has one or more levels of aluminium foil surrounding the copper mesh (for minimum loss AND to minimise interference).

Attenuation is expressed in dB/100m and increases as frequency increases. Because we're not talking super high frequencies (~250MHz and less) you can be a bit less fussy in selecting coax.

But really, if you're making this antenna because you need all the signal you can get to avoid the digital cliff, buy the best coax you can afford, within reason.

If the length of coax lead-in needs to be relatively long and there are splitters to serve more than one TV set this becomes even more important.

When the antenna is mounted on its mast, make sure the coax is firmly secured to that mast (and to the antenna boom) with *black* cable ties (for best UV protection), otherwise the cable can flap around in the wind.

There is nothing more annoying than lying in bed late at night and listening to the cable slapping against the mast!

Cable ties are cheap: use them!

An astonishing technological breakthrough in TV antennas . . . (!)

Every now and then a product comes along that totally rewrites the laws of physics, the laws of electronics, the laws of commonsense and probably the laws of gravity and decency (among others!).

Such is the 230 x 102mm TVFox Antenna, available only online, which appeared as banner advertising on a couple of what could only be described as suspect Australian websites. It was pointed out to us by SILICON CHIP reader George B.

Thanks for bringing it to our attention!

Since then, we've also seen variants of these (one called the "TVSurf") offering similar remarkable (and totally unjustifed) "benefits" – including a testimonial from "William of Perth" who claimed that "this antenna saved him tons of money". Exactly the same testimonial can be found on other websites. William sure gets around!

George wanted to know if these so-called "super antennas" could do what they appeared to claim – that is, pick up subscription TV channels for free.

We have to say that this has some of the most creative copywriting we've seen in a long, long time. For a start, nowhere do they actually claim that they can receive pay TV channels – but the very name, TVFox Antenna, is misleading in the extreme.

They claim that there is a law which forces all cable companies to also transmit their programming on free-to-air channels – and this is what the super antenna receives.

Well, we don't know if such a law does exist in the US (we seriously doubt it!) . . . but we do know there is no such law in Australia. In fact, the exact opposite applies, making it illegal to view subscription or pay TV programs without paying for them!

Other claims make for fascinating reading: *"designed using discrete military tech"* (whatever that means!).

*"Mount your razor-thin TVFox antenna anywhere – behind your TV or a picture frame . . .*etc etc" Oh yeah? Sure, you could mount it there, but would it receive anything (especially shielded by your TV!)? We'd like to see that!

"Up to 30 mile range" Not even with a downwind! And notice the "up to" – that means it could be 30-inch range!

"Allows you to receive hundreds of free television programs in your area without complicated setups or monthly contracts."

The "antenna" is completely passive. But even if it had an inbuilt (powered) amplifier we doubt it would receive anything, unless you could reach out and touch the transmitter! Maybe.

There's even a photo on one website of it mounted on the side of a caravan – with no apparent connection to the TV set above. Is there no end to the TVFox wizardry?

Then there's the price: $35.74 – not too expensive (if it worked), except that's in US dollars. So it's more than $AU45! Oh, but you do "qualify" for $5.00 shipping – only if you order today! (And that's US$ too!).

So if you were to buy one, it's going to cost you more than $AU50 to find out that you're not exactly overjoyed with its performance!

In a word, it's a con – and our advice is to run the proverbial mile away if you see one. We'll give you the URL just so you can have a good ol' chuckle yourself. But whatever you do, don't be conned into buying one – no matter how good it sounds!

Be amazed yourself, via **siliconchip.com.au/link/aaii**

SC

Motion Sensor & Soil Moisture Sensing Modules

Using Cheap Asian Electronic Modules Part 13

This month we look at two low-cost modules from Elecrow. One is a motion sensor which uses microwave Doppler radar technology rather than passive IR sensing, while the other module is designed to sense the soil moisture level in a garden or pot plant. Both modules can be easily interfaced with an Arduino or Micromite device.

Let's start by looking at the Elecrow RCWL-0516 Microwave Radar Motion Sensor module first. It measures only 36 x 17 x 4.5mm, including the on-board transmit/receive antenna.

Essentially, this module is designed as a replacement for passive IR movement sensors as used in intruder alarms, movement-actuated lighting and movement-sensing toys.

It's designed to work on any DC supply voltage between 4V and 28V, with an operating current under 3mA. The UHF oscillator/mixer transmits a signal at around 3.2GHz, with an output of between 20mW and 30mW.

This is claimed to provide movement sensing at distances of up to 7 metres, with close to 360° of coverage from the front of the module.

Additional features include the ability to adjust the trigger repeat time and the sensing distance, plus the ability to use a CdS (cadmium sulphide) LDR (light dependent resistor) to disable the sensor at night if desired.

The trigger repeat time is nominally about two seconds, but an optional SMD capacitor labelled "C-TM" can be added on the back of the PCB to increase this time if desired.

Similarly, a 1MΩ resistor "R-GN" can be added on the back of the board to reduce the sensing range from 7m to 5m.

The optional LDR is added to the front of the board if it's desired to disable the sensor at night. This would probably only be used for applications like movement sensing toys because for many other applications, the main use of the sensor would be at night anyway.

This motion sensor's circuit

The circuit for the RCWL-0516 sensor module is shown in Fig.1. The UHF oscillator/mixer is on the left, using Q1, an MMBR941 NPN transistor. The low-frequency Doppler signal output from Q1 is fed to pin 14 of IC1, which forms the triggering circuit.

By JIM ROWE

IC1 is an RCWL-9196 device, for which no data seems to be available. However, it's claimed to be very similar to the BISS0001 "micropower PIR motion detector" IC used in many of the passive IR motion sensors.

The oscillator/mixer circuit around Q1 is interesting because of the use of PCB track components rather than discrete ones. It appears to be a Colpitts circuit, with capacitors C_{BE} and C_{CB} formed by inter-track capacitance and the inductor/antenna comprising an S-shaped track forming a microstrip line on the top of the PCB.

Notice that the microstrip inductor not only forms a key part of the oscillator circuit but also serves as the antenna for both transmission and reception.

The circuit around Q1 is not just an oscillator and transmitter but also serves as a mixer, to combine the transmitted and received signals and deliver the resulting Doppler difference frequency.

This appears as a relatively small low-frequency signal across the 2.0kΩ

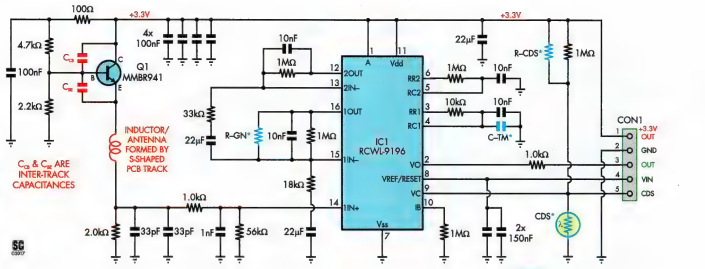


Fig.1: complete circuit diagram for the Elecrow RCWL-0516 microwave radar motion sensor module. The track inductor forms the antenna for both transmission and reception of microwave signals and has a range of approximately 7m.

resistor connecting the "cold" end of the inductor/antenna to ground, which then passes through a low-pass RC filter before being fed to input pin 14 of IC1.

Inside IC1, the signal apparently passes through two stages of amplification and filtering and is then used to trigger one of a pair of timers. This timer provides the module's "movement sensed" pulse at pin 2 (V_O), while the other timer sets the trigger repeat time.

Optional resistor R-GN is connected between the output (1OUT) and inverting input (1IN-) of the first gain op-amp inside IC1, so clearly, the sensing range is reduced by lowering the gain of this stage. On the other hand, optional capacitor C-TM is used to increase the capacitance from the RC1 pin (pin 4) to ground, to extend the trigger repeat time.

IC1 has an internal 3.3V regulator. This is used to step down the supply voltage fed to the module via the V_{IN} pin (4) of CON1 and then into IC1 itself via pin 8.

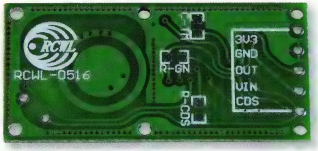
The output of the regulator not only powers IC1's internal circuitry but is also made available via pin 11 (V_{DD}), where it's used in this case to power the microwave oscillator/mixer stage around Q1. It can supply up to 100mA of current to external loads, via pin 1 of CON1.

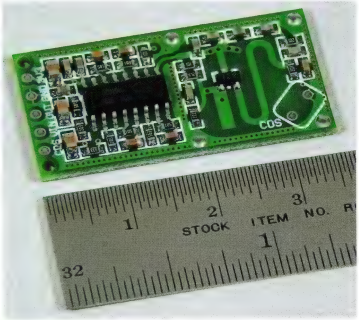
Another point to note is that pin 9 of IC1 allows the chip's triggering to be disabled. As you can see, this pin (V_C) is pulled high to 3.3V, as well as being brought out to pin 5 (CDS) of CON1.

So triggering is normally enabled but it can be disabled quite easily, either by shorting pin 5 of CON1 to ground or by fitting the optional CdS LDR to the module.

When an LDR is fitted, its resistance drops when the ambient light level increases, pulling the voltage at pin 9 of IC1 down. Once it drops to below 0.2V, triggering is disabled.

The purpose of optional resistor R-CDS is presumably to allow fine tuning of the light level at which triggering is disabled when the LDR is fitted. This is useful since LDRs vary quite a bit in their light/resistance characteristic.





Both photos show the microwave-based motion sensor module at just over twice normal size (36 x 17mm). The PCB has numerous vias to connect the top and bottom layer ground planes. An odd feature of this module is that nearly all the optional parts (R-GN, R-CDS & C-TM) are soldered to the bottom of the PCB instead of the top; with the exception of the LDR (marked CDS).

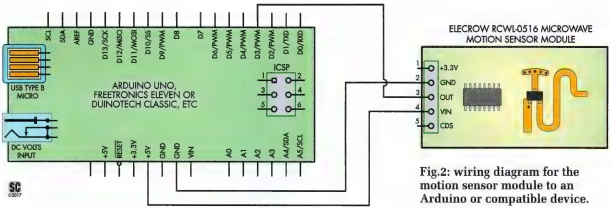


Fig.2: wiring diagram for the motion sensor module to an Arduino or compatible device.

Connecting to a micro

Fig.2 shows a very simple way of connecting the RCWL-0516 motion sensor module to an Arduino micro. The V_{IN} and GND lines connect to the +5V and GND pins of the Arduino, while the OUT pin (pin 3 of CON1) connects to pin D3. That's all there is to it.

It's just as easy to connect the module to a Micromite, as you can see from Fig.3. Here the V_{IN} and GND lines again connect to the corresponding pins on the Micromite, while the OUT pin connects to pin 16.

In both cases, the actual pin of the micro to which the OUT pin of the module is connected is purely to suit the program you'll be using to monitor the sensor's output. We've shown the connections in Fig.2 and Fig.3 merely because they are intended to match the simple programs we will now discuss.

Programming it

It's easy to get the RCWL-0516 module working with either an Arduino or a Micromite, as all it needs in each case is a few brief lines of code.

On the SILICON CHIP website, you'll find two short programs which show just how easily it can be done. The file "RCWL0516_motion_sensor.ino" is suitable for an Arduino.

When you download it, verify and compile it using the Arduino IDE and then upload it to your Arduino, you should find that when you open the IDE's Serial Monitor, you see a sequence of one-line messages from the module like this:

```
No movement detected:  Output = LOW
No movement detected:  Output = LOW
Movement detected:     Output = HIGH
```

The messages will be coming at the rate of two per second, and you'll soon find that moving anything within the module's sensing area will immediately result in the "Movement detected" message.

To use the module with a Micromite, download "RCWL0516 motion sensor check.bas" and use MM Edit to upload it to your Micromite.

You'll find that it works in much the same way as the Arduino program but with one exception; as well as sending messages back to your PC, this one also provides a display on the Micromite's LCD screen (assuming you have the LCD BackPack).

Elecrow's soil moisture sensor

Now let us take a quick look at the Elecrow CT0007MS Soil Moisture Sensor module, which is essentially an updated version of earlier analog soil moisture sensors.

Although this module is much simpler than the microwave movement sensor we've just looked at, it's on a somewhat larger PCB because its two sensor probes form about 70% of the PCB area. The overall size of the module is 60mm long by 20mm wide.

Each probe is formed by gold-plated tracks on both sides of the PCB, connected together with 11 vias in each case. You can see this fairly clearly from the lead photo of the module.

Also visible in the photo is the 210mm long three wire lead which is supplied with the module and used to hook it up to a micro. The connecting lead is provided with a 3-way line socket at each end, one of which mates

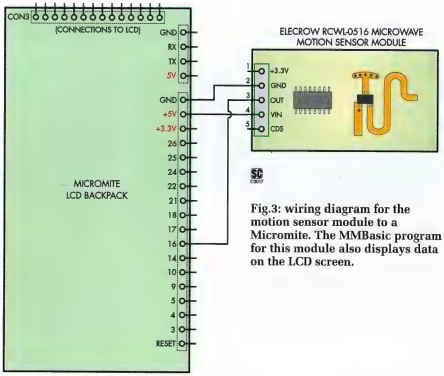


Fig.3: wiring diagram for the motion sensor module to a Micromite. The MMBasic program for this module also displays data on the LCD screen.

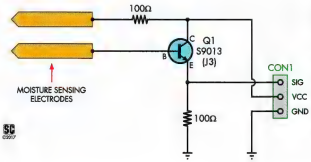


Fig.4: circuit diagram for the Elecrow CT0007MS moisture sensor. Q1 is connected as an emitter-follower such that the voltage across the 100Ω resistor at the emitter is proportional to the soil moisture level.

with the plug on the module itself.

Fig.4 shows the circuit of the CT-0007MS module. Which is just an emitter-follower using NPN transistor Q1.

When the two probe electrodes are pushed into the soil, they form a resistance whose value is inversely proportional to the moisture present in the soil.

As this resistance is effectively between the DC supply rail (V_{CC}) and the base of Q1, this means that its base current will vary according to the soil moisture. Ergo, wetter soil equals a lower resistance in the base circuit and a higher base current.

Because Q1 is connected as an emitter-follower, this means that the voltage across its 100Ω emitter resistor will also be proportional to the soil moisture level.

The wetter the soil, the higher the voltage across the resistor due to the higher base current. Since the voltage across the resistor forms the signal (SIG) output from the module, this voltage will also vary according to the soil moisture.

So the CT0007MS module is essentially just an analog transducer converting soil moisture into a DC voltage. In order to use it with a micro, all that's needed is to feed its SIG output to one of the micro's (analog to digital converter) inputs and to connect its V_{CC} and GND inputs to the corresponding supply lines.

Fig.5 shows this connected with an Arduino, while Fig.6 shows it with a Micromite. The module's V_{CC} lead can be connected to either the +5V line or the +3.3V line. To emphasise this, we've connected it to the Arduino's +5V line, but to the +3.3V line in the case of the Micromite.

Programming this one

Programming an Arduino to use the CT0007MS moisture sensor module is straightforward. All you need to do

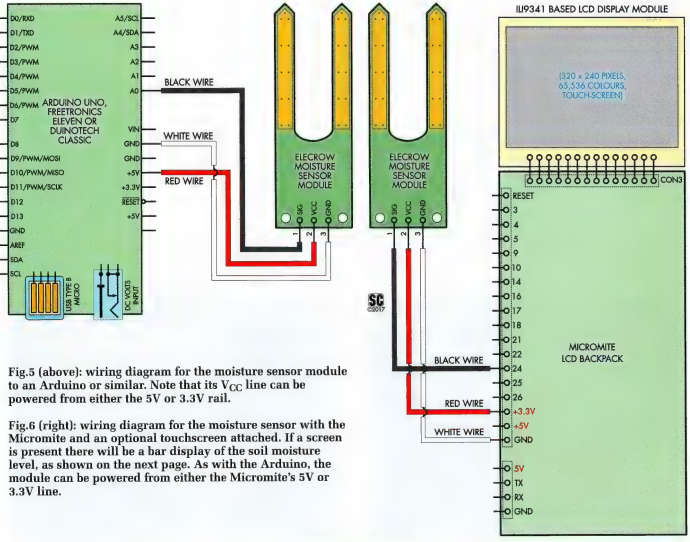


Fig.5 (above): wiring diagram for the moisture sensor module to an Arduino or similar. Note that its V_{CC} line can be powered from either the 5V or 3.3V rail.

Fig.6 (right): wiring diagram for the moisture sensor with the Micromite and an optional touchscreen attached. If a screen is present there will be a bar display of the soil moisture level, as shown on the next page. As with the Arduino, the module can be powered from either the Micromite's 5V or 3.3V line.

is read the module's SIG output voltage. The higher the reading, the more moisture in the soil.

To get you going with this, we have produced a simple little program called "CT0007MS_moisture_sensor.ino" which is available for download from the SILICON CHIP website.

Use the Arduino IDE to upload it to your Arduino and you should find that it will start printing out (via the IDE's Serial Monitor) moisture readings from the sensor every two seconds, as shown in the screen grab.

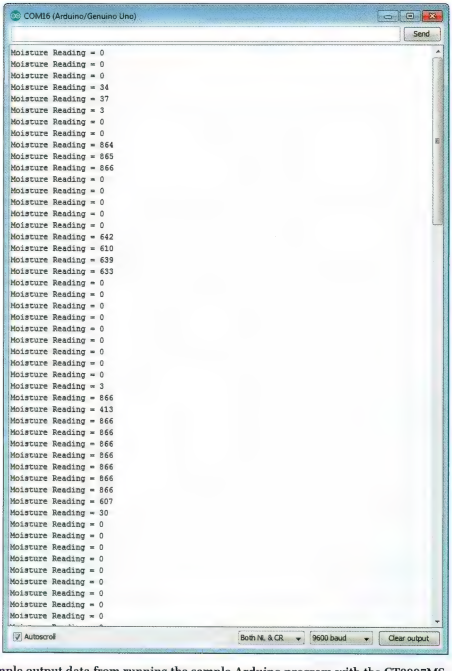
During our test, the sensor probes were inserted into soil a number of times. On the last occasion the soil was quite wet, resulting in readings of around 866 (out of 1023). On the other hand, the readings were zero (0) when the probes were not inserted into any soil.

We've also written a small program to show how easy it is to use the sensor with a Micromite. It's called "CT-0007MS moisture sensor.bas" and as before, it's available from the SILICON CHIP website.

This program produces the same sort of printout of moisture readings (a feature of MM Edit) as the Arduino program. But if your Micromite is connected to an LCD panel, it will also display a bar graph on the screen, indicating the current moisture level.

You can see this in the two small screen grabs below, one showing the display when the soil is fairly dry and the other showing the display when it's very wet.

Hopefully, these two simple programs will give you a good introduction to what's possible using the Elecrow CT0007MS module. SC



Above: example output data from running the sample Arduino program with the CT0007MS.

SMART POWER
ECO POWER SOLUTIONS

Jaycar Electronics

NOW $149
SAVE $20

SOLAR POWER PACK WITH LED LIGHTS

MB-3697 **WAS $169**

All-in-one solar power solution for the garage, shed, caravan, boat, or even tent! 12V 4Ah AGM built-in battery. 5.0VDC USB socket for charging Smartphones or Tablets. 5W monocrystalline solar panel with stand.

- 2 x 3W cool white LED lights

FROM $249

12V FOLDING SOLAR PANELS

A convenient and portable power solution! Monocrystalline panels. Built-in PWM solar charger and 5m lead to charge your battery.

- Compact and lightweight
- Aluminium frame
- Carry bag for portability

100W ZM-9174 **$249**
120W ZM-9176 **$299**
160W ZM-9178 **$399**

LEARN ABOUT... PWM vs MPPT

Maximum Power Point Tracking (MPPT) devices convert excess solar panel voltage to electrical current with power conversion efficiencies up to 97%. Pulse Width Modulation (PWM) devices regulate the solar panel voltage using switching techniques and suited for small-medium power applications (max 60A). MPPT offers high scalability and is suited for charging battery or connection to power grid.

NOW $249
SAVE $20

12V 15A HIGH POWER 4-STAGE BATTERY CHARGER

MB-3710 **WAS $269**

Designed to quickly recharge 12V lead-acid batteries (wet, sealed, AGM, etc) with a high level of efficiency and charge current. Microprocessor controlled. Auto-start feature. Electrically isolated output.

- 205(L) x 130(W) x 70(D)mm

NOW $39.95
SAVE $10

12V 8A WATER RESISTANT PWM SOLAR CHARGE CONTROLLER

MP-3720 **WAS $49.95**

Suitable for both wet-cell and sealed lead-acid batteries. Uses pulse width modulation (PWM) for optimal 3-stage charging.

- Over current/voltage, reverse polarity protections
- 97(L) x 46(W) x 26(H)mm

Visit website for full specifications

SAVE $100!

NOW $349
SAVE $100

50A MPPT SOLAR CHARGE CONTROLLER

MP-3731 **WAS $449**

Highly intelligent charge controller for use with solar installations up to 95VDC. Use with 12, 24, 36, or 48V battery banks. Uses maximum power point tracking (MPPT) for maximum efficiency and charge rate.

- Overcharge, under-voltage, and reverse current protection
- 202(W) x 235(H) x 88(D)mm

500W WIND TURBINE GENERATOR

MG-4550

PRICE BREAKTHOUGH! $899

Harness free energy from the wind. Marine grade, rugged and salt corrosion resistant. Built-in MPPT charge controller.

- 12/24V charging
- Carbon fibre composite blades
- Weight: 6.7kg

Visit website for full specifications

POWERBOARD & EXTENSION LEAD COMBO

MS-4039 **WAS $49.95**

4 way round cable reel with 15m extension lead. No tangles, no fuss, and it's already set for next use. Heavy duty case.

- Master power switch
- Overload protection
- 193(W) x 253(H) x 160(D)mm

NOW $39.95
SAVE $10

GREAT SAVINGS!

NOW $199
SAVE $40

4 OUTLET 10A POWER BLOCK - IP44

MS-4086 **WAS $29.95**

Spring loaded outlet covers. Integrated overload protection.

- Water resistant
- 1.8m cable length
- 264(H) x 185(W) x 183(D)mm

NOW $24.95
SAVE $5

VARIABLE LABORATORY AUTOTRANSFORMER (VARIAC) MP-3080 **WAS $239**

Encased in heavy-duty steel housing, this unit enables the AC input to a mains powered appliance to be easily varied between 0 to full line voltage (or greater). A must for testing mains performance.

- 500VA (fused) rated power handling
- On/off switch
- 0–260 VAC @ 50Hz output voltage
- 165(D) x 120(W) x 160(H)mm

VISIT OUR BRAND NEW STORE IN FRANKLIN, VIC

CONTROL POWER USING ARDUINO®

TECH TIP:

RELAYS

Relays are a great way for controlling power but aren't capable of being directly controlled by a microcontroller such as an Arduino®, but using our relay modules, this restriction is overcome.

SINGLE RELAY MODULE

XC-4419

Needs an external source of 5V power, so is suitable for USB powered projects, but only needs about 3V to activate, so can be used on 3.3V microcontrollers and even single board computers like the Raspberry Pi or PCDuino, as long as 5V can be sourced for '+'.

$5.45

FROM $12.95

XC-4440

XC-4418

FOUR & EIGHT RELAY MODULES

Rely on an external 12V (9V-14.4V should work fine) power supply to operate their coils, and also feature opto-isolators so that the 12V circuit can be kept separate to the low voltage circuit by removing the COM-GND jumper.

4 CHANNEL XC-4440 **$12.95**

8 CHANNEL XC-4418 **$19.95**

$12.95

MOTOR CONTROL MODULE XC-4472

Has 2 x 5V servo ports connected to the Arduino's high-resolution dedicated timer to ensure jitter-free operation. Control up to four DC motors or two stepper motors.

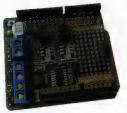
- 5V to 16VDC
- 70(L) x 53(W) x 20(H)mm

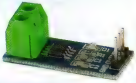
$7.95

24V 5A MOS DRIVER MODULE XC-4488

Accepts Pulse Width Modulated (PWM) input to drive 24VDC loads when connected to an Arduino. Perfect for many projects such as lighting, dc motors, pumps and solenoid.

- 3.3V & 5V DC operation
- Output current 5A
- 34(L) x 21(W) x 16(H)mm



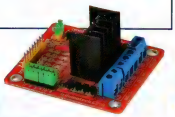


$9.95

30A CURRENT SENSOR MODULE XC-4610

Outputs a voltage proportional to current passing through the sense pins on the module. Uses ACS712 hall effect sensor.

- Output ratio is 66mV/A
- 31(L) x 13(W) x 15(H)mm



$14.95

DUAL MOTOR CONTROLLER MODULE XC-4492

Allows full control of two DC Motors or one stepper-motor. An on-board 5V regulator can be used to power your project.

- Motor voltage: 3-30VDC
- Requires six digital inputs
- 69(W) x 56(D) x 36(H)mm

NOW $19.95

SAVE $10

H-BRIDGE MOTOR DRIVER SHIELD

XC-4264 **WAS $34.95**

Provides PWM (Pulse-Width Modulation) motor output on 2 H-bridge channels to let your board control the speed, direction and power of two motors independently. All outputs are diode and back-EMF protected.

- 60(W) x 54(H) x 12(D)mm

$4.95 ea

L293D DUAL FULL BRIDGE MOTOR DRIVER IC

ZK-8890

Capable of providing four high power outputs to drive a stepper motor or two DC motors. 3.3V or 5V.

- 16pin DIP IC
- 600mA current drive per channel

$3.95

L9110 SINGLE BRIDGE MOTOR DRIVER IC ZK-8882

Compact 8 pin DIP package which can control a small motor from a microcontroller.

- 2.5V- 12V, 800mA

$9.95

9G MICRO SERVO MOTOR YM-2758

Small enough to connect directly to an Arduino Board. Perfect for use with our pan and tilt bracket (XC-4618 $4.95) sold separately.

- 3.5-6VDC. 1.6kg.cm @ 4.8

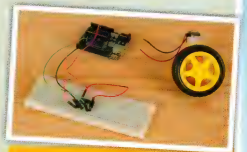
$9.95

DC GEARED MOTOR WITH RUBBER WHEEL

YG-2900

Suitable for your Arduino® vehicle based/robotics applications.

- Working voltage 5-10VDC
- 48:1 gear ratio
- 66i(Dia.) x 28(W)mm



CHECK OUT OUR ONLINE GUIDE FOR USING THESE IC'S WITH MOTORS AND ARDUINO
www.jaycar.com.au/power_and_arduino

$34.95 ea

SERVO MOTORS WITH METAL GEARS

High speed and high torque digital servos with dual ball bearings and metal gears for maximum strength and durability. Excellent replacement for the standard servos commonly used in all 1/10th and many 1/8th scale remote control cars or for use in any number of robotics applications.

- 4.8V - 7.2V
- 40 x 19 x 42mm

13KG YM-2763

11KG YM-2765

PROJECT OF THE MONTH

RTC POWER POINT TIMER

Using Arduino to control a 240V appliance but don't want to get zapped? Well then, here is your solution. We've developed a project that interfaces to our MS-6148 Remote Controlled Mains Outlet using a 433MHz transmitter and adding some extra code, gives you a mains timer with the following features:

- Switch on/off appliances with a minute of resolution
- Keeps time during power off
- Programme up to 99 timers
- Can be set for any or all days of the week, weekdays or weekends
- Can be set to turn single channel or all channels on or off
- Manual control of transmitter for setup and troubleshooting

And being Arduino®, there's nothing to stop you taking the code apart and adding your own features.

NERD PERKS CLUB OFFER
BUY ALL FOR $69.95
SAVE OVER $30

VALUED AT $103.75

SEE STEP-BY-STEP INSTRUCTIONS AT: jaycar.com.au/RTCpowerpointtimer

WHAT YOU NEED:

UNO MAIN BOARD	XC-4410	**$29.95**
DATALOGGING SHIELD	XC-4536	**$19.95**
LCD SHIELD	XC-4454	**$19.95**
REMOTE CONTROLLED MAINS OUTLET	MS-6148	**$19.95**
WIRELESS 433MHZ TRANSMITTER MODULE	ZW-3100	**$13.95**

DON'T FORGET THE MAKER ESSENTIALS

$11.50

POLYMORPH PELLETS NP-4260

Softens to be formed into any shape at around 62 - 65°C. It can be drilled, sanded, ground, machined or heated and reformed again and again.

- 100g bag of 3mm pellets

$14.95

1L PCB WASH DEFLUXING SOLUTION NA-1070

Removes flux and residue from circuit boards to provide an extremely clean and contaminant free surface.

- Non-flammable
- Water- based (biodegradable)

$14.95

BREADBOARD WITH 830 TIE POINTS PB-8815

Ideal for electronic prototyping and Arduino® projects. Labeled rows and columns. Adhesive back for mounting.

- 200 Distribution holes
- 165(L) x 54(W) x 9(H)mm

$3.95

INSULATION TAPE - 6 ROLLS NM-2806

One roll each of green, black, yellow, white, blue and red. Each 5m in length.

- 19mm wide.

$14.50

HEATSHRINK PACK WH-5520

1 length each of 7 different colours in 7 different sizes ranging from 1.5mm dia to 20mm.

- Sizes: 1.5, 3, 5, 6, 10, 16 & 20mm

$14.95

JUMPER LEAD MIXED PACK WC-6027

A mixed pack of jumper leads for Arduino®, breadboarding and prototyping projects.

- 150mm long
- 100 pieces

ADD MORE OUTLETS TO YOUR PROJECT

$39.95

MAINS OUTLET WITH REMOTE CONTROL MS-6147

Turn any standard mains outlet on/off via remote! Great for hard-to-reach power points. 30m range. Remote control up to 4 outlets.

- Mains outlet : 97(L) x 55(W) x 60(D)mm

ALSO AVAILABLE

SPARE MAINS OUTLET MS-6149
WAS $12.95 NOW $9.95 SAVE $3

CAPTURE THE SUN'S POWER

SEMI FLEXIBLE SOLAR PANELS

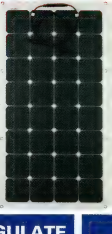
Ideal for mounting to curved and other irregular surfaces such as an RV roof or boat. 12VDC.

30W ZM-9151 **$129**

100W ZM-9155 **$349**

LIGHT AND LESS BULKY

FROM $129



$9.95 ea

ANDERSON® 50A POWER CONNECTORS

Used widely in both domestic and industry applications. Supplied as a moulded 2 pole with contacts.

- 50A, 600V (AC or DC)

WITH 6 GAUGE CONTACTS PT-4420
WITH 8 GAUGE CONTACTS PT-4425
WITH 10-12 GAUGE CONTACTS PT-4427

$19.95 ea

SOLAR PANEL 'Y' LEADS

Used for connecting the output of two solar panels in parallel or connecting multiple panels in an array. Waterproof and UV resistant.

2 SOCKETS TO 1 PLUG PS-5110
2 PLUGS TO 1 SOCKET PS-5112

CONTROL & REGULATE

NOW $49.95
SAVE $20

20A SOLAR PANEL REGULATOR

MP-3126 **WAS $69.95**

Massive 20A current. Easy to install and does not require a heatsink.

- Completely automatic
- Battery or solar power LED indication
- Reverse polarity protected
- 66(L) x 51(W) x 34(H)mm

MASSIVE SAVINGS!

FROM $59
SAVE UP TO $80

SOLAR CHARGE CONTROLLERS

Protect solar installation and maximise battery service life. Features adjustable charging voltage, automatic dusk-till-dawn on/off, overload protection, etc.

- Microprocessor controlled
- 150(W) x 85(D) x 45(H)mm

20A 12VDC MP-3129 **WAS $129 NOW $59 SAVE $70**
30A 12VDC MP-3722 **WAS $169 NOW $89 SAVE $80**

STORE

$89.95

BATTERY BOX WITH POWER ACCESSORIES HB-8500

Designed to fit a 100Ah deep cycle battery. LED voltmeter, two high current cigarette power sockets, and bolt terminals.

Limited stock.

FROM $249

12V AGM DEEP CYCLE BATTERIES

Designed to store large amounts of energy. Superior deep cycling performance for many different recreational and industrial applications such as camping, boats, motorhomes etc.

75AH SB-1680 **$249**
100AH SB-1682 **$299**

CONVERT

FROM $279

MODIFIED SINE WAVE INVERTERS WITH USB AND LCD DISPLAY

Power handheld power tools, televisions, gaming consoles, home electronics and small appliances in your car, truck, boat or RV. 12VDC to 230VAC. Short circuit / overload protection. Dual USB port. Remote control.

1100W MI-5140 **$279**
1500W MI-5142 **$399**
2000W MI-5144 **$549**

FROM $499

PURE SINE WAVE INVERTERS WITH SOLAR REGULATORS

Perfect for off-grid solar power system in caravans, yachts, holiday houses and where inverters are used. Connect a solar panel directly to charge the connected battery. 12VDC.

600W 20A SOLAR REGULATOR MI-5720 **$499**
1000W 30A SOLAR REGULATOR MI-5722 **$599**
1500W 30A SOLAR REGULATOR MI-5724 **$799**

TEST & PROTECT

NOW $19.95
SAVE $5

INTELLIGENT 12V/24V BATTERY TESTER QP-2263 WAS $24.95

Versatile battery tester for vehicle or vessel batteries

- LCD panel of voltage as well as LED indication for under/overcharge
- Suitable for 12V and 24V batteries
- 75(W) x 48(H) x 19(D)mm

NOW $79.95
SAVE $5

12VDC LEAD ACID BATTERY TESTER QP-2261 WAS $84.95

Tests most automotive cranking lead acid batteries, including an ordinary lead acid battery, AGM flat plate, AGM spiral, and GEL batteries.

- 8-30VDC voltage range
- 125(L) x 70(W) x 25(H)mm

Battery not included

NOW $29.95
SAVE $5

INLINE RCD CIRCUIT BREAKER

QP-2002 **WAS $34.95**

Protect against electrocution and equipment damage. 10A. 240VAC.

NOW $79.95
SAVE $10

PORTABLE POWERPOINT WITH RCD MS-4044 WAS $89.95

Convert your 15A power lead to fit standard 10A power outlet.

- 2m mains lead
- 10A circuit breaker/RCD earth leakage protection.

NOT FOR USE IN THE RAIN OR EXPOSED TO WEATHER

TECH TIP:

DUAL BATTERY SYSTEM EXPLAINED

Portable 12VDC appliances and equipment, such as refrigerator or safety flood lights, are great for the recreational outdoors or the tradesman on the road, however these devices require plenty of battery power. If connected to a vehicle's main battery they will quickly deplete the vehicle's main battery. No use enjoying a cold beer outdoors, but you can't get home because your car won't start. Hence an auxiliary battery is normally installed to power the additional equipment.

There are a few challenges to consider when wiring in an auxiliary battery; the auxiliary battery must not affect the normal charging cycle of the main battery at the same time the auxiliary battery must receive enough power to charge during normal running of the vehicle.

A DC-to-DC boost charger is used to connect the auxiliary battery to the vehicle's power, it provides the required electrical isolation to prevent the auxiliary battery from affecting the operation of the main battery, as well as delivering a regulated charging voltage to ensure the auxiliary battery is reliably charged.

Our MB-3690 DC-to-DC boost charger is capable of taking an 8-16V DC input voltage, and delivering a stable, regulated 13.8V/14.4V 4-stage charging output to reliably recharge the auxiliary battery. It's also easy to mount and wire up.

Keep your house batteries topped up on the run.

BASIC SET-UP FOR LIGHT USE SYSTEMS

NOW $149
SAVE $10

140A DUAL BATTERY ISOLATOR KIT WITH WIRING MB-3686 WAS $159

Allows two batteries to be charged from your engine alternator at the same time. Emergency override feature. LED status indicator.

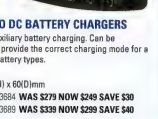
- 67(L) x 67(W) x 53(H)mm

See website for contents

ALSO AVAILABLE:

125A DUAL BATTERY ISOLATOR (VSR) MB-3687 **$49.95**

ADD THIS TO BASIC SET-UP FOR FASTER & ACCURATE CHARGING



FROM $249
SAVE UP TO $40

12/24V DC TO DC BATTERY CHARGERS

Ideal for 12V auxiliary battery charging. Can be programmed to provide the correct charging mode for a wide range of battery types.

- 9-32VDC
- 180(W) x 134(H) x 60(D)mm

12/24V 20A MB-3684 **WAS $279 NOW $249 SAVE $30**
12/24V 30A MB-3689 **WAS $339 NOW $299 SAVE $40**

OR USE ONLY THIS FOR FAST ACCURATE CHARGING & EASY INSTALLATION

NOW $349
SAVE $50

4 STAGE 40A DC TO DC BOOST CHARGER

MB-3690 **WAS$399**

Capable of taking an 8-16VDC input voltage and giving a stable, regulated 13.8V/14.4V output to give your auxiliary battery a full 100% charge. Output current is rated 40A to ensure a quick charge.

- 260(L) x 140(W) x 80(H)mm

SF-2249

FROM $39.95

BATTERY ISOLATOR SWITCHES WITH AFD

Durable and rated for massive output. Features alternator Field Disconnect (AFD) to protect alternator.

275A 2POSITION SF-2249 **$39.95**
200A 4POSITION SF-2250 **$49.95**

SF-2265

$26.95 ea

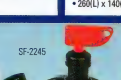
HIGH CURRENT DC CIRCUIT BREAKERS

Rugged and reliable. Feature protective rubber caps, test button and gold plated 5mm diameter terminals.

- 12-14VDC

70A CIRCUIT BREAKER SF-2265
100A CIRCUIT BREAKER SF-2266

SF-2245



FROM $17.95

BATTERY ISOLATION SWITCHES

High current for high power applications. Features high quality construction with large bolt down terminals for electrical connection.

120A 12V SF-2245 **$17.95**
500A 12V SF-2247 **$59.95**

FT-4440

FROM $14.95

HIGH CURRENT LEADS

Easily adapt or extend your 50A Anderson connector with the following 300mm long adaptors or 5m extension.

5M EXTENSION LEAD	PT-4440 **$79.95**
PIGGYBACK LEAD	PT-4442 **$34.95**
EYE TERMINAL	PT-4444 **$14.95**
15A CIGARETTE PLUG	PT-4446 **$16.95**
15A CIGARETTE SOCKET	PT-4448 **$16.95**

HC-4030

$9.95 ea

UNIVERSAL BRASS BATTERY TERMINALS

Heavy duty, solderless, marine grade brass battery terminals perfect for isolating your battery to prevent battery drain when not in use. Sold in pairs.

SADDLE HC-4030
LUG BOLT TYPE HC-4034

$8.95 ea

SF-1990

GOLD ANL WAFER FUSES

Features gold finish screw-down contacts for maximum current transfer and conductivity. Designed for high current applications.

80A SF-1990
100A SF-1992
150A SF-1995
200A SF-1997
250A SF-1999

LEAD ACID BATTERY CONDITIONER

NA-1420

Removes or reduces sulphation which kills batteries. One bottle will do up to a N70Z size battery (4WD, boat, truck, etc.)

- 92ml

$8.95

$4.15 /m

HIGH CURRENT POWER CABLES

56A 8 gauge OFC. Sold per metre.

BLACK WH-3062
RED WH-3060

WORKBENCH ESSENTIALS

There has been an obvious resurgence in people getting back to the workbench and reviving skills involving manual dexterity. As you will see across the following pages, Jaycar has all the DIY tools you'll need to equip your workbench so you can create projects from the power of your brain and your hands.

1. 3 WAY ROUND POWERBOARD MS-4043 **WAS $19.95**
- Integrated into a handy cable reel for safe, tangle free storage
- 3m Extension lead
- Overload protection
- 47(H) x 149(D)mm

2. PORTASOL PRO PIEZO GAS SOLDERING KIT TS-1329 **WAS $159**
- 120 minutes run time, 10 seconds fill, and 30 seconds heat up
- Maximum 580°C tip temperature (max 1300°C for built-in blow torch)

3. SOLAR POWER METER QM-1582 **WAS $129**
- Optimises solar panel installations by finding optimum locations for the panels
- Expressed as W/m² (Watts per square metre), or BTU/ft² (British thermal units per square foot)
- 63(W) x 162(H) x 28(D)mm

4. CAT III NON-CONTACT AC VOLTAGE DETECTOR QP-2258
- Detects AC voltages from 50 to 1000V
- Green and red LED indicators
- LED flashlight function
- 2 x AAA batteries included
- 158(L) x 23(D)mm

5. ANTI STATIC FIELD SERVICE MAT/BAG TH-1778
- Ideal for field service people
- Mat folds out to work area of 600 x 600mm (approx)
- 2 pouches at one end
- Grould lead and wrist strap included

6. TRUE RMS DIGITAL MULTIMETER QM-1551
- Higher accuracy
- Autoranging
- Measure AC and DC (600V), Current (10A)
- Non-contact voltage detection and temperature

RS SERIES ENCLOSED POWER SUPPLY

Ideal use for industrial, automation, appliances, medical equipment etc.
- Single output
- 15/25W
- 5VDC to 24VDC
- No load power consumption 0.2W to 0.75W

See website for full range

MP-3295

FROM $19.95

LRS SERIES ENCLOSED POWER SUPPLY

Ideal use for industrial control system, mechanical & electrical equipment, electronic instrument etc.
- Single output
- 35/50/75/100/150W
- 5VDC to 24VDC
- No load power consumption 0.2W to 0.75W

See website for full range

MP-3285

FROM $29.95

GST SERIES DESKTOP POWER SUPPLY

Ideal for use with various types of consumer electronic devices, office facilitites, industrial equipment etc.
- 60W/120W
- 12/24/48V
- 90-264VAC input
- No load power consumption 0.2W to 0.75W

See website for full range

MP-3252

FROM $49.95

13.8VDC 12A LAB POWER SUPPLY

MP-3079

Fused input, fixed output voltage.
- 13.8VDC output voltage
- 12A output current
- 170(W) x 160(L) x 85(H)mm

$69.95

0-24VDC 15A COMPACT LAB POWER SUPPLY MP-3800

Compact size, high current & variable output.
- 0-24VDC output voltage
- 15A output current
- Analogue meter (backlit) screen
- 148(W) x 162(D) x 82(H)mm

$149

0-32VDC 0-3A DUAL OUTPUT LAB POWER SUPPLY MP-3087

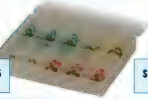
Automatic constant-voltage /constant current. Operate two outputs independently.
- 2 x 0 - 32VDC output voltage
- 2 x 0 - 3A output current
- Backlit LED screen
- 185(H) x 260(W) x 400D(mm)

$399

$39.95

300PC QC CRIMP CONNECTOR PACK PT-4536

Contains the most commonly used quick connectors and joiners in various sizes and colours. *See website for full specifications.*



$34.95

42PC ASSORTED SOLDER SPLICE HEATSHRINK PACK WH-5668

Quickly create sealed soldered joint in one go.

See website for full contents.

$29.95

RETRACTABLE TEST LEADS WT-5334

Set of 3 heavy duty leads with insulated alligator clips in a handy retractable reel. 3m long.

$8.95

5 WAY CRIMPING TOOL TH-1828

Cuts and strips wire. Can also cut bolts with diameter M2.6, M3.0, M3.5, M4.0 & M5.0.

EXCLUSIVE CLUB OFFERS:

FOR NERD PERKS CLUB MEMBERS

WE HAVE SPECIAL OFFERS EVERY MONTH. LOOK OUT FOR THESE TICKETS IN-STORE!
NOT A MEMBER? Visit www.jaycar.com.au/nerdperks

20% OFF 20% OFF 20% OFF SOLAR PANEL MOUNTING HARDWARE

NERD PERKS CLUB OFFER

2 FOR $35

MAINS POWER METER
MS-6115 **ORRP $24.95 EA**
VALUED AT $49.90

SAVE 25%

NERD PERKS CLUB OFFER

FREE

PP-1981
CIGARETTE LIGHTER POWER LEAD*

5M WATERPROOF LED FLEXIBLE STRIP LIGHT
ZD-0576

ONLY $79.95

*PP1981 valued at $19.95. Valid with purchase of ZD0576

NERD PERKS CLUB OFFER

JUST $299

BUNDLE DEAL
1 X OUTDOOR CAMERA QC-8048 **$179**
1 X SOLAR PANEL CHARGER QC-8045 **$149**
1 X WIRELESS IR FLASH QC-8044 **$99.95**
VALUED AT $427.95

SAVE $128.95

NERD PERKS **SAVE 20%**

PIEZO REVERSING BUZZER
AB-3464 **REG $12.95 CLUB $9.95**
4-16V operating voltage.

NERD PERKS **SAVE 10%**

RJ45 PLUG 8 PIN FOR STRANDED CABLE PP-1437 **REG $14.95 CLUB $12.95**
Pack of 10.

NERD PERKS **SAVE 20%**

LEAD FREE SOLDER 200G
NS-3094 **REG $24.95 CLUB $19.95**
99.3% tin, 0.7% copper lead-free. 1mm

NERD PERKS **SAVE 20%**

100G POCKET SCALE
QM-7258 **REG $49.95 CLUB $39.95**
Weighs in grams, carats, pennyweight or ounces.

NERD PERKS **SAVE 15%**

RED 15A DC POWER CABLE
WH-3054 **REG $11.95 CLUB $9.95**
10m roll.

NERD PERKS **SAVE 20%**

COMPACT STEREO AMPLIFIER
AA-0518 **REG $99 CLUB $79**
2 x 20WRMS. Gold plated terminals.

NERD PERKS **SAVE 10%**

CCD CAMERA EXTENSION LEAD
WQ-7277 **REG $44.95 CLUB $39.95**
15 metre.

NERD PERKS **SAVE 20%**

M205 FUSE PACK
SF-2242 **REG $12.95 CLUB $9.95**
Pack of 40.

NERD PERKS **HALF PRICE!**

PROBE K TYPE THERMOCOUPLE
QM-1282 **REG $14.95 CLUB $7.45**
Plug in probe.

NERD PERKS **SAVE 20%**

50VA STEPDOWN TRANSFORMER
MF-1091 **REG $49.95 CLUB $39.95**
240VAC to 115VAC.

NERD PERKS **SAVE 25%**

USB RJ45 EXTENSION ADAPTOR
XC-4684 **REG $29.95 CLUB $21.95**
Transmitter and receiver included.

NERD PERKS **SAVE 10%**

TRANSISTOR PACK
ZT-2170 **REG $16.95 CLUB $14.95**
100 Mixed BC series transistors.

NERD PERKS CLUB MEMBERS RECEIVE:

20% OFF

SOLAR PANEL MOUNTING HARDWARE*

*Includes Solar Panel Mounting Bracket, ABS Solar Panel Mounts & ABS Solar Cable Entry Point.

YOUR CLUB, YOUR PERKS:
DON'T FORGET TO USE YOUR JAYCOINS CARD WITHIN 6 MONTHS OF ISSUE
Conditions apply. See website for T&Cs.

WHAT'S NEW

WE'VE HAND PICKED JUST SOME OF OUR LATEST NEW PRODUCTS. ENJOY!

LED DRIVERS

High efficiency, low power, complies with latest domestic and international lighting regulations.

APV SERIES

Suitable for indoor use as decorative lights, strip lights in kitchens, robes and bathrooms.

- Indoor use
- 12/16W
- Plastic case
- Low power
- IP42 rated

See website for full range

12/24V OPTIONS

MP-3371

FROM **$29.95**

LPF SERIES

Suitable use for LED lighting and moving sign application i.e panel lights, downlights & tunnel lights.

- Indoor or outdoor use
- 40/60W
- Plastic case
- Medium power
- IP67 rated

See website for full range

12/24V OPTIONS

MP-3374

FROM **$79.95**

ELG SERIES

Suitable use for LED street lighting and outdoor LED lighting i.e architectural lights, sign lights and flood lights.

- Indoor and outdoor use
- 75/150W
- Metal case
- High power
- IP67 rated

See website for full range

12/24V OPTIONS

MP-3378

FROM **$99.95**

$49.95

200A DC WATT METER & POWER ANALYSER MS-6190

All-in-one power meter, volt meter, amp-hour meter, ammeter and energy meter.

- 75A continuous / 200A Max

WITH ANDERSON CONNECTOR OPTION AVAILABLE MS-6192 **$59.95**

FROM **$59.95**

12/24V PWM SOLAR CHARGE CONTROLLERS WITH TIMER FUNCTION MP-3756

High efficient PWM charging. Automatically recognizes day/night. LED indicators for PV and battery status.

- IP67 protection
- Load overload and short circuit protection

10A MP-3756 **$59.95**

20A MP-3758 **$89.95**

$79.95

2 X 15WRMS PORTABLE STERED AMPLIFIER AA-0504

Connects to any passive 4 ohm speakers. Accepts standard audio line output from any sound system.

- Intelligent short-circuit / over-temp protection
- 152(W) x 106(D) x 52(H)mm

Image may very to the one shown.

$149

HDMI 18GBPS REPEATER AC-1728

Will provide a boost to run HDMI signals over long distances.

- Scale up, down, or pass-through
- 20m @4K 60Hz, 40m @1080p distance
- Maintains quality over long cable extensions

$59.95

ANALOGUE RGB LED STRIP KIT SL-3942

Totally flexible and self-adhesive strip. Mains power supply included.

- Remote controlled
- Waterproof

$19.95

RGB UNDERWATER LIGHT SL-3933

Select up to 12 different colours and 3 different light patterns. IP65 rated with a max depth of 2m.

- Requires 3 x AAA batteries

$14.95

LOGIC PROBE KIT KD-6100

This logic probe will help you diagnose and troubleshoot your 3.3V or 5V circuits, including Arduino and Raspberry Pi projects. It indicates a logic low or logic high state on the green and red LEDs, and shows a shift between states on the orange LED. Kit supplied with double-sided screen printed PCB and specified parts.

TERMS AND CONDITIONS: REWARDS / NERD PERKS CARD HOLDERS FREE GIFT, % SAVING DEALS, DOUBLE POINTS & MEMBERS OFFERS requires ACTIVE Jaycar Rewards / Nerd Perks Card membership at time of purchase. Refer to website for Rewards/Nerd Perks Card T&Cs. PAGE 3: Nerd Perks Card holders receive special price of $89.95 for RTC Power Point Timer Project I) x XC-4410 + 1 x XC-4536 + 1 x XC-4454 + 1 x MS-6140 + 1 x ZW-3100 when purchased as bundle. PAGE 7: Nerd Perks Card holders gets FREE Cigarette Lighter Power Lead (PP-1981) with purchased of ZD-6576 5m Waterproof LED Strip Light. Nerd Perks Card holders receive special price of $289 for Outdoor Bundle Deal (1 x OC-8048 + 1 x OC-8065, 1 x OC-8044) when purchased as a bundle. 20% OFF on Solar Panel Mounting Hardware applies to Jaycar 4006 Panel Mounting Hardware.

NEW STORE: NORTH LAKES

Unit 2/51 Flinders Parade, North Lakes, 4509 QLD

PH: 1800 022 888

FOR YOUR NEAREST STORE & OPENING HOURS:

1800 022 888

www.jaycar.com.au

96 STORES & OVER 140 STOCKISTS NATIONWIDE

Jaycar Electronics

Head Office
320 Victoria Road,
Rydalmere NSW 2116
Ph: (02) 8832 3100
Fax: (02) 8832 3169

Online Orders
www.jaycar.com.au
techstore@jaycar.com.au

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. Those stores may set buy-in stock of those items and can not order or transfer stock. Savings off Original RRP. Prices and special offers are valid from Catalogue Sale 24 January - 23 February, 2018.

SERVICEMAN'S LOG

Smart TVs can be pretty dumb sometimes

Dave Thompson*

It might surprise a few readers to know that despite constantly teetering on the bleeding-edge of technology in my day job, my home life is surprisingly low-tech.

You'd imagine that after 40-plus years of building gadgets and magazine projects from all ends of the hobby electronics spectrum, my home would be bristling with automatically-opening this and clap-your-hands-to-turn-off that.

You'd think my car would have reversing bleepers, wiper delay controls, electronic ignition, radio boosters and all that flash kit. While it does actually have those features, none were built by me, rather, they all came standard with the car. In fact, there is very little in my car with my soldering signature on it.

What's the old saying? A plumber's pipes are always rusty, a cobbler's children always have bare feet or something along those lines...

When it comes down to it, a lot of the gadgets I built in the past have become outdated and were replaced by cheaper and better commercial versions.

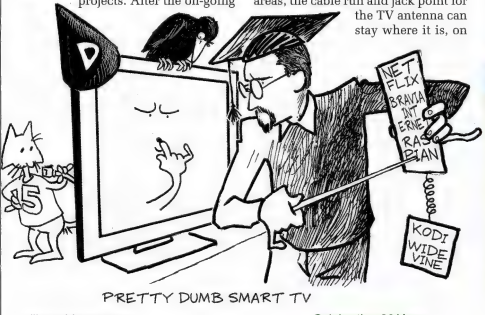
I'm also what buzz-word fans like to call time poor, in that I have little time left in my day to devote to building projects. After the on-going (and seemingly never-ending) work renovating my workshop, fixing up the interior of the house and trying to run a business, free time is a luxury I don't presently have much of.

The point behind all this is that we don't have a lot of high-tech appliances and gadgetry at home; we don't even have our set-top box wired up to watch terrestrial TV, and getting Sky or similar cable TV seems like an expense we can't justify with the amount of goggle-box watching we currently do.

Perhaps we'd watch more if we had all that stuff in place but for just one example, to get that set-top box working, I'd need to re-route the connector and cable from the external TV antenna that the previous homeowner installed on the roof. And that would involve crawling through cramped, humid, spider-web-covered and dusty roof spaces.

Given that I'm no longer 20 years old and find it increasingly difficult to mould myself into some of the shapes required to navigate these areas, the cable run and jack point for the TV antenna can stay where it is, on the exact opposite side of the room to where our TV sits.

In times past, I've rigged a temporary antenna extension cable strung across the carpet in order to both check the socket worked and to test a very funky little set-top box that a very kind, industry-connected serviceman sent to me from Australia to ensure it worked in NZ. But stringing a longer extension cable around the periphery of this room is not feasible, nor is it a tidy long-term option.



PRETTY DUMB SMART TV

Joining the 21st century

I only mention all this because the other day I saw an offer for joining the streaming internet TV service Netflix and began to think about how that would work in our household. The advertisement listed some up-coming shows that piqued my interest, so I thought I'd mention it to my wife and see what she thought of the idea.

Unbeknownst to me, she'd seen the same promotion and mentioned it to me first, so we discussed it and decided to sign up for a month's free trial and see what all the fuss was about. It all seemed straight-forward enough; my wife mentioned that several people at

Items Covered This Month

- Smart TV versus a smart Kiwi
- Samsung S24D390 monitor repair
- Fixing two 750W 230VAC/12V DC GMC generators
- Switchmode power supply with a blown fuse

*Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

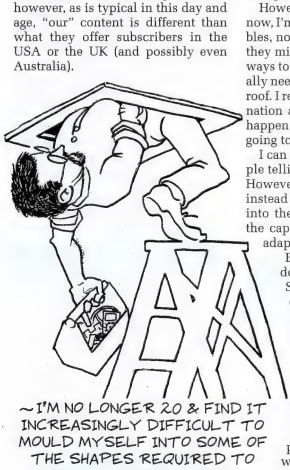
her workplace were Netflix customers and highly recommended it.

They'd simply plugged their smart TV into their local network, signed in using the Netflix app on the TV and away they went. This sounded far too easy, yet it ironically in-part explains why my company no longer has any bread-and-butter work to do.

Years ago, we made a respectable living out of setting up clients' broadband modems and local networks; now customers are supplied modems that are pre-configured to work out of the box. No more setting IP ranges, subnet masks, MAC addresses or default gateways. Nowadays everything is done automatically and is truly "plug and play".

Of course, one gets the odd situation where things don't quite go so smoothly but typically a phone conversation with the relevant helpdesk soon has the customer up and running, and all without a tech in sight.

I signed up with Netflix on their website and once logged in, clicked around it on my computer to check it out. They have a lot of content that I considered worth having a look at, however, as is typical in this day and age, "our" content is different than what they offer subscribers in the USA or the UK (and possibly even Australia).



It appears the same old zoning, monopolising and price-fixing practices extend even to this media broadcast system. Still, there seems to be enough to keep us occupied for our first free month's trial and after that, we'll have to see where we stand.

All I need to do now is to get Netflix working on my eight-year-old 40" Sony Bravia TV and we will be good to go.

Watching a two-and-a-half-hour film sitting at the computer, or worse, on a smartphone screen might be a good night in for millennials, but I'd rather watch anything longer than the average Mr Bean sketch on a decent-sized screen and be sitting comfortably in a proper chair.

Connecting the TV

The first thing I'd need to do is connect the TV to our local network. This means plugging a Cat5 network cable into the LAN socket on the TV and running it to the nearest network switch. Unfortunately, that sits around 15 metres from the TV, as the crow flies (not that we get a lot of crows in our living room!).

However, as might be apparent by now, I'm not into running external cables, no matter how carefully hidden they might be and with several doorways to contend with as well, I'd ideally need to run the cable through the roof. I refer you to my previous explanation as to why this isn't likely to happen. Underfloor is also out so I'm going to need another way.

I can already hear the cries of people telling me to go wireless instead. However, Sony was way ahead of me; instead of building WiFi capability into the TV, they helpfully provide the capability for using an external adapter.

But I can't use any old WiFi dongle, I need to buy a special Sony WiFi dongle, which of course costs a small fortune. This immediately triggers my "stick-it-in-your-tail-pipe" response, so I won't be going down that road.

In the meantime, I suppressed my aversion to exposed cabling and laid a temporary cable around the walls. After all, there's no point in getting carried away with buying hardware or installing anything permanent until we are sure we'll stick it out past the free trial period.

With the cable plugged into the router and the TV, and all the relevant lights flashing to indicate connectivity, I sat down to see what we had working. Reassuringly, there is an "Internet TV" button on the remote controller, so I started by pushing that.

Straight away I ran into a problem. A menu popped up with a selection of options, all of which were not available to select, except one, which was the Bravia Internet option. When I selected it though, after a moment 'thinking' about it, a message popped up telling me that I wasn't connected.

After a little more button-pushing on the remote, I found a network setup section, and after running the rudimentary "wizard" was informed that the network was OK, the internet was available and the TV was ready. When I went back to the Bravia Internet menu and selected it, I still went nowhere.

But this time I got a message saying I had to register my smart TV with Sony so I could access their internet services. To do this, I'd have to return to my computer and register the TV online. That only took a few minutes, and after entering a code provided by the TV, the set was registered with "my devices" at my new Sony Entertainment account, and the buzz was mounting. We were ready to go!

By the time I'd walked back into the lounge, the TV was displaying a message telling me it was registered. This time, when I selected Bravia Internet, a dialogue appeared and went back and forth for a minute or so while I was "authenticated" before an error code popped up telling me I needed to register my Bravia. What the .. !?!

After trying a few more times to make sure it wasn't a temporary glitch, I resorted to the internet. It seems hundreds of people had the same problems and it appeared to be related to the age of the TV. While this model is around eight years old, it's not as if it's from 1975; surely it couldn't be relegated to the heap so soon?

Eventually, after much gnashing of teeth and wringing of hands (and the odd swear word), I found a new firmware download for this model of TV. After copying the downloaded file to a flash drive, I put it in one of the two USB ports on the rear of the set and rebooted the TV.

The update file was automatically

detected and took around three minutes to complete. The set restarted and all the settings had been retained, which was quite good; many firmware updates reset everything to default. In this instance, it didn't matter because I didn't have any custom settings in there anyway!

This time, when I tried the Bravia Internet, I logged on to the Bravia Entertainment Network and was instantly completely underwhelmed by the choices offered.

There was a grand total of five channels available, three of which no longer worked and the others were so lame content-wise that watching paint dry would have been like a summer blockbuster. What a rort…

Once again, I hit the web; I was under the impression Netflix would be natively available, but of course, when this TV was made, Netflix was just an idea someone was working on.

The firmware was dated 2014, but still nothing there either. According to consensus online, my TV was too old and even though it is a "smart" TV, it is apparently too dumb to receive today's content.

Not to be beaten

We had another option, my LG Blu-ray home theatre system. This device boasted a network socket in the back so I plugged that in and fired it up. Sure enough, there was a Netflix app listed there, so I selected it and waited. And waited some more. After about 30 seconds, I was asked to sign in, which I did, painfully, using the remote control as a text-input keyboard, and then hit enter and waited some more.

Finally, Netflix loaded, and I selected a title and hit Play. I then waited for the documentary to load, the status of which is indicated by a progress bar at the bottom of the screen. After about 30 seconds, the bar stopped. After another minute or so waiting, I tried pressing buttons, but to no avail; the system had hung.

Luckily, I'd found out how to hard-boot this device when working on it once before; like many computers, holding the power button down for 5-10 seconds trips off the power.

After restarting it, I tried loading another title. After the same loading wait, it started playing. It seems the progress bar gets to about 30% while it is buffering before starting the media. On the previous try it must have hung just as the title started to play, but this time it did start.

However, our joy was short-lived when we started playing with the forward and reverse controls. On the computer, these actions are quick and perform like any other on-screen media-player menu. On the TV, it was painfully slow. It is actually so bad that it is unusable, and our excitement at this stage was turning to bitterness. How did other people get on with all this kerfuffle?

Flashing firmware and configuring players isn't the gold-standard for internet TV surely? The people my wife talked to said they had no worries, or so they claimed. Once again, we felt like we were the only people who had problems with this stuff.

To all those armchair techs out there whose heads are swimming with possibilities, let me add some figures; we have a 200mbit fibre pipe into this house, though at speedtest.net our tests consistently achieve readings in the high 90s down and 40 up, so while underperforming, our speed should be more than adequate for streaming media.

The Blu-ray player might be a few years old and the TV apparently now pre-historic but I had still assumed that our experience would be better than it was.

But I wasn't done yet. I have a Raspberry Pi and my memory banks had stored the fact that people were using them as entertainment centres. Apparently, all I needed to do was download and run a Linux-based home-theatre software system named Kodi, and I'd be away.

This I did, and soon had Kodi running, but once again, while I had a gazillion available add-ons, offering everything from German sports to Arabic news, I had no Netflix, which further research blamed on licensing problems. This was becoming very tiresome and I'd spent a lot of time I didn't have to spare on getting this thing to work.

Then I had the thought of just running Raspbian, the Raspberry-Pi's normal operating system, and running Netflix on the included Chrome-based web browser. This actually worked, but again not very well; it appears the Pi doesn't have the processing grunt to run this at high resolutions.

With the browser in full-screen mode, any movie stuttered horribly. In windowed mode it was watchable, but who wants to watch a 1024x768 window on a 40-inch screen?

While I was trying all this, my wife discovered that some bright spark had found a way of getting Netflix to work with Kodi but it required a beta version, which I eventually found and downloaded. After some more downloading and installation of add-ons, we finally had the Netflix app installed.

It even let us sign in, but as soon as I tried to play a movie, it crashed with an error, and further research revealed that I needed another resource called Widevine, a DRM decrypter and well, at this point, I ran out of excitement and concluded that it is just too difficult.

Maybe I was over-thinking it. Maybe my expectations were too high. Maybe it just isn't up to what I would call scratch yet.

Regardless, I ended up plugging the cable back into the Blu-ray player and making do with that. I've also put an order in for Gigabit internet, which is five times faster and actually cheaper than what we pay now. We'll see whether that improves Netflix's loading and fast-forward/reversing times.

I have since read about people using the likes of ChromeCast to relay content from computers, tablets and phones to their TVs but having to do that seems unwieldy and a bit naff.

To my mind, it should just work, especially if they want us to stay on and pay for it.

Technology... when it works seamlessly, it may have the appearance of magic but when it doesn't, it's more like having a voodoo curse or a hex upon your head!

Samsung S24D390 monitor repair

J. W., of Hillarys, WA, is a generous sort and so he recently offered to fix his friend's monitor, which appeared to be on the way out. Luckily for him, it didn't turn out to be a terribly expensive or difficult job. Here's what happened...

A pensioner friend recently asked me to look at his 24-inch Samsung LCD monitor. He said the top third of the screen was going dim after some hours of use but was OK next time he turned it on. It was only a few years old and he did not want to throw it away and get another.

So I connected it to the Raspberry Pi in my shed and left it running. When I came back some time later, sure enough, the picture was intact but the top third of the screen was dull as if the backlight had stopped working.

I found a central screw on the back of the monitor and removed it. I then had to use some plastic prying tools to undo the numerous plastic tabs holding the back on.

Inside, I found a small PCB which contained all the electronics with three cables connected to it. One large ribbon cable went to the LCD panel itself, another went to the switch panel on the front of the monitor. The third went to the front of the monitor and when I checked the PCB, the labels indicated they were for LEDs 1-3. So this was for the LED backlight system.

As there were only four wires in the cable, I assumed one was for power and the other three were the low-side drive lines for the three sections of the screen: top, middle and bottom.

I powered up the monitor again and it performed normally so I traced the tracks from the backlight connector to find three transistors connected to the main controller IC.

The output of each also had a resistive divider that sent a portion of the output voltage back to the main controller. So the controller was able to monitor the operation of the backlight system and disable it if it appeared to be faulty.

I measured the voltages on each transistor and found all to be identical. After a short time, not enough for the monitor to warm up properly (especially with the back removed), the top third of the backlight went off. I checked the voltages on the three transistors again and found one which did not match the others.

So was the problem the transistor, the controller chip, the connections or the LED backlight itself?

I decided to figure out where the fault lay by swapping two wires in the backlight connector that plugged into the PCB. This would move the fault to another third of the screen if the driver electronics were at fault.

The fault returned after a short time with the top third of the screen dull as before. This proved the fault was indeed in the backlight assembly and not the controlling electronics.

The next step was to try to disassemble the LCD panel and backlight to see if I could identify the fault. The LCD panel came away easily enough once I had removed a number of screws. I was able to hinge it out of the way as there was a flexible connector at the bottom edge.

However, once I checked under the panel, I found that access to the backlight system was from the back.

I had a good view of the backlight diffuser and when I tapped the side of the monitor, the top backlight would flicker and eventually go off and come back on when I turned the power off and on. So it seemed the problem was some sort of bad connection and the controller was detecting the problem and disabling the faulty section.

I decided to remove the LCD panel entirely to make it easier to access the backlight system.

The area around the back of the monitor was again held in place by plastic tabs so a bit of prying with a small plastic tool got it apart. I could now see the diffuser used to spread the light from the side-lit LED system. The LEDs were in a long strip that appeared to be glued to the side of the metal case, so getting at them seemed to be impossible.

At this stage, I noticed a 2x3mm piece of metal which moved when I shifted the monitor. It was sitting at the bottom of the string of LEDs. I removed it with a pair of tweezers and decided there was no more I could do to fault find any further at this stage.

After reversing the disassembly process and letting the monitor run for a number of hours, the fault did not return. So I have to assume that the piece of metal was sitting in a posi-

tion where it was occasionally shorting something out and causing the controller to switch that section of the backlight off.

I ran the monitor for a few days with no sign of the fault returning, so my friend had his monitor back at no cost. The only mystery was where this piece of metal had come from. Maybe it broke off something else in the monitor. I guess we'll never know.

Two generators for the price of one

B. P., of Dundathu, Qld, recently had problems with two similar generators. He faced the typical challenges of sourcing suitable parts but managed to find a valid substitute. In the process, he discovered an interesting design aspect of the alternator. Here is his story...

Several years ago, we bought a GMC 750W 230VAC/12V DC generator, which we used a few times initially, including powering a PC with a CRT monitor. It was then put in the shed and not used for quite a few years.

Recently, I took it out to use it and I found that it no longer worked. The two-stroke motor ran OK but there was no electrical output from either the 230VAC outlet or the 12V DC outlet. As the generator had been barely used and it was still like new, I was a bit surprised by this.

I suspected that it might have stuck brushes as a result of sitting unused for several years. The first job was to remove the fuel tank, which was held on with four bolts. This then revealed the top of the unit and all the wiring.

I then proceeded to remove the outer casing from the alternator so that I could check to see what problem may exist.

I could find nothing wrong inside. There were no brushes in this alternator, as it works on a different principle to a car alternator. There was a field coil and a wound armature but no brushes, so it was a bit of a mystery to me as to how it actually worked. A car alternator (many of which I have repaired) has brushes (and slip rings) and a regulated field supply from the battery.

Despite not fully understanding how it worked, I decided to investigate further. I identified the motor ignition coil and the ignition module but then I spotted what appeared to be a large black capacitor. I removed this capacitor and I noticed a physical defect in it, so this was most likely the cause of the problem (see photo at the upper right).

This capacitor was rated at 10µF and 350VAC, so I started looking on eBay for a replacement. At first, I had a lot of trouble finding anything remotely resembling this capacitor, as what was showing up was smaller types that are more common.

Then, several pages later, I found what I was looking for but this capacitor was really expensive. However, I noticed that it was called a "generator capacitor", so I changed my search criteria to that and now I had a lot more of the correct type of capacitor showing up but they were mostly 12µF and not 10µF.

I gave the matter some thought and I decided to order a couple of the 12µF capacitors and take a chance that they would work, as they were a lot more common than the 10µF capacitors and a lot cheaper as well.

The capacitors arrived, so I fitted one and I tried to start the generator. However, now it wouldn't start. I removed the spark plug and I found that I had no spark on the plug, but I had a spark on the lead. This type of thing often happens with two-stroke engines.

I heated the plug with my blowtorch and re-fitted it and then I managed to start the generator but I would need to replace the spark plug later. However, it was running now, so I took the opportunity to test it to see if it was producing any electricity.

My multimeter showed that I had 230VAC at the AC outlet and around 14V DC at the DC outlet, so it was now working. I grabbed a bed lamp and this lit when turned on, so I then got out my angle grinder to see if it would work on the generator.

This angle grinder has a 625W motor and the generator's rated output is 550W (750W peak). The generator ran the angle grinder OK but it did make the motor work a lot harder. So the 12µF capacitor was fine as a replacement for the original 10µF capacitor.

The large black capacitor located in the generator with a fairly obvious crack in its casing.

One down, one to go

Later, I just happened to be looking for something in my shed and I found another one of these GMC generators which was the same model as the original one. I couldn't remember where this generator came from, but I most likely got it when I helped a friend clean out his shed a couple of years ago and I brought a few "goodies" home.

This second generator had no fuel tap; it had broken off and the fuel line had gone hard. I needed a new fuel tap for our original generator too because the handle part had broken, so I ordered a couple of fuel taps and some fuel line on eBay.

The fuel taps arrived but I then noticed that the outlet was on the opposite side to the original, so I couldn't use them. I hadn't noticed the orientation at the time I ordered them but further searching located fuel taps with the outlet at the bottom instead of the side, so I ordered this type and waited for them to arrive.

In the meantime, I had a look at the second generator and gave it a clean, as it was quite dirty. While doing this, I removed the capacitor to check it and I found that it was in fact 12µF.

This was interesting. I did notice a slight variation between the two generators, as this second one did not have

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in Silicon Chip? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

The two GMC 750W generators. The first generator to be repaired, which provided no electrical output from AC or DC, is on the right while the second, which had no fuel taps, is on the left

the flap over the 230VAC outlet like the original generator had.

So, I wondered whether this 12µF capacitor was the original capacitor that had been fitted to this generator by the manufacturer or if it had been replaced at some stage in the generator's life, before I got it.

While I was waiting on the fuel taps and the fuel line, I thought I would use the fuel tank from the original generator to give this second generator a test. After fitting the fuel tank, I tried to start the generator but it would not start. I had already replaced the spark plug and I had spark, so it must be a fuel problem.

I removed the spark plug and put a few drops of fuel into the cylinder, then replaced the spark plug and tried to start it again. It fired and ran for around a second, so that meant that fuel was not getting through. I removed the carburettor and took the bottom bowl off it and I noticed some dirt in it.

I cleaned this out and removed and cleaned the main jet, which was blocked, before reassembling the carburettor and re-fitting it.

Now the engine started and I went through the process of checking it with my multimeter and angle grinder. The generator worked just the same as the original one, so now I had a second working generator.

Once the new fuel taps and the fuel line arrived, I fitted them, then reassembled both generators and put them away ready to be used whenever the need arises. For a small outlay for parts and a bit of work, I now have two working generators, a good result in my book.

Editor's note: brushless alternator designs are attractive because they have a much longer service life due to the lack of brush wear. For those curious about how they work, the following excerpt from Wikipedia should help:

"A brushless alternator is composed of two alternators built end-to-end on one shaft. Smaller brushless alternators may look like one unit but the two parts are readily identifiable on the large versions."

"The larger of the two sections is the main alternator and the smaller one is the exciter. The exciter has stationary field coils and a rotating armature (power coils)."

"The main alternator uses the opposite configuration with a rotating field and stationary armature. A bridge rectifier, called the rotating rectifier assembly, is mounted on the rotor."

"Neither brushes nor slip rings are used, which reduces the number of wearing parts. The main alternator has a rotating field as described above and a stationary armature (power generation windings)."

"Varying the amount of current through the stationary exciter field coils varies the 3-phase output from the exciter. This output is rectified by a rotating rectifier assembly, mounted on the rotor, and the resultant DC supplies the rotating field of the main alternator and hence alternator output."

"The result of all this is that a small DC exciter current indirectly controls the output of the main alternator."

Switchmode power supply repair

R. W., of Mt Eliza, Vic, recently had a friend present him with a faulty electronic module from an unknown appliance to fix. They must consider him to be an electronic whiz and he may be, for he soon had it working again. As follows...

My friend brought the anonymous module over and told me that it had failed but didn't give me any more information about it. On inspection, I found it to be a 110-240VAC input switchmode power supply with no protection cage around it. I briefly applied power and discovered that the fuse had blown. So I told my friend to leave it with me and I would see what I can do.

I asked him to give me some further information about the board, eg, what piece of equipment it was out of or any circuit diagrams he might have but nothing was forthcoming. As mains switchmode power supplies can be dangerous, I was not looking forward to working on it.

Despite using the PCB part number as a search keyword and trawling the internet, I was not able to find a circuit or any information and I did not know who manufactured the equipment it was from, so I could not search for that either.

I noticed there were two wire links installed on the PCB and a position for a high-power resistor which was vacant. The links were evidently supposed to be installed for 110VAC operation and omitted for 240VAC. And the missing 27kΩ resistor was supposed to be installed for 240VAC and omitted for 110VAC.

This explained why the fuse had blown; the PCB was configured for 110VAC but had been plugged into 230VAC mains. At least this was a start. I could easily remove two wire links and solder in a high-wattage 27kΩ resistor once I found one. But what else had blown before the fuse?

I decided to remove the board from the chassis and see if I could trace the circuit around the wire links. I found that it uses a full-wave bridge rectifier for 240VAC operation (when the wire

links are not installed) but it functions as a half-wave voltage doubler when the links are installed for 110VAC operation. I also noticed that there appeared to be a thermistor wired in series which had burned out.

There were also two optoisolators on the board. One seemed to be used to indicate to the control circuit when the AC input was present. I think this signal may be important when power is first applied but I did not trace the circuit further to find out.

For 110VAC input, the optoisolator was connected via a 27kΩ resistor to the incoming AC line. For 240VAC input, there was an extra 27kΩ resistor in series. When the wire link is installed it shorts out the second 27kΩ resistor.

But for cost-saving reasons, the manufacturer did not install the second resistor when factory configured for 110VAC input. This made me question whether the optoisolator may have been blown when 230VAC was applied.

I thought at this point I might as well make the changes required for the unit to operate from 230VAC, plug it in and see if it worked. I didn't have much to lose; if anything else had failed, it would probably just blow the fuse when powered up.

I didn't have a replacement thermistor but even though a chunk had blown out the side, the resistance across its pins didn't seem too high at 32Ω. This was probably higher than a good thermistor but still low enough to allow the power supply to operate with a light load. At least I would know if it still worked.

So I made the changes and replaced the fuse. I didn't have the correct slow-blow type of fuse on hand so I decided to use a regular fuse for testing purposes. I hoped that the inrush current at start-up would not blow it. Sometimes, you have to try your luck!

I put the PCB back into the chassis and sat it on top of a cardboard box to ensure that it was insulated from the top of the workbench. I connected the mains power cord via an earth leakage circuit breaker and switched it on at the power circuit.

The fuse did not blow but there was a loud crack as a spark shot out of the side of the thermistor.

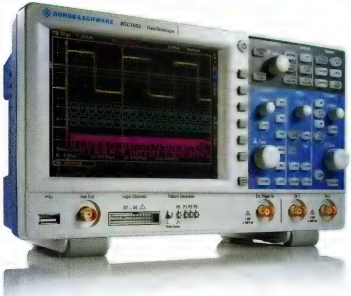
Without touching the power supply, I carefully connected my Fluke multimeter across each of the DC output connectors. The voltages measured +5.1V DC, +11.95V DC and -11.96V DC. Whoopee! All was OK; I guess one can be lucky sometimes. But I still needed to replace the thermistor and put in a proper slow-blow fuse.

On Saturday morning I made a trip to the local electronics store and fitted the new parts that afternoon. The power supply passed a no-load voltage test. Luck was on my side. The fuse had blown before any damage was done other than to the fuse and thermistor. The power Mosfet was clearly OK and the optoisolator had not blown up with only one 27kΩ resistor in circuit.

I made a phone call to my friend to tell him that it was ready to be picked up. We decided to have a BBQ on Sunday and he would collect the power supply at the same time.

I did not hear from him whether the power supply worked OK when installed into whatever it came from. I suppose if it had not worked, he would have let me know straight away. Sometimes no news is good news! SC

New Rohde & Schwarz oscilloscopes



Rohde & Schwarz have recently introduced the two-channel RTC1000 series, a compact, low-cost, high-quality digital storage oscilloscope.

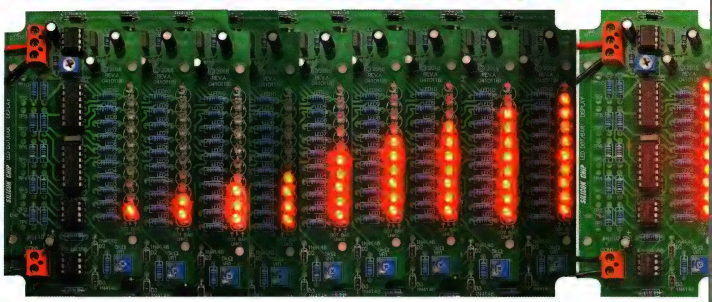
It can double as an eight-channel logic analyser, four-channel pattern generator and a protocol analyser for I^2C, SPI, UART/RS-232, CAN and LIN; and as a digital voltmeter, component tester, spectrum analyser and counter. With this eight-in-one instrument integration, users get more value with a minimal footprint on bench space.

R&S RTC1000 oscilloscopes are available with bandwidths from 50MHz to 300MHz. Bandwidth upgrades are available via software license all the way to 300MHz and can be purchased as needed. The maximum sample rate is 2 GSample/s and memory depth is 2 Msamples. LAN and USB interfaces are standard.

SILICON CHIP is expecting to obtain an R7A4000-series scope/spectrum analyser (another new product) for review in the near future.

For further information contact:
Rohde & Schwarz
Ph: (02) 8874 5100
Email: sales.australia@rohde-schwarz.com
Website: www.rohde-schwarz.com/RTC1000

A 10-LED Bargraph with



Want a really flexible bargraph? This 10-LED Bargraph will fill the bill. It can be configured for dot or bar mode, while for audio signal monitoring, extra circuitry can be added to provide for VU or for Peak Program Metering (PPM). It's a worthy replacement for the now-discontinued LM391X series of bargraph chips.

LED bargraph displays are ubiquitous – you will find them everywhere, in all sorts of electronic equipment.

They can be horizontal, vertical, curved, circular or other shapes. They give an immediate visual indication of operating conditions, whether monitoring voltage levels or physical parameters such as temperature, audio signal level or whatever and they can be designed to react rapidly or slowly.

While many displays these days are digital read-outs, bargraphs are much better at showing variations in level, especially if those variations happen quickly.

This 10-LED Bargraph indicates DC voltage levels in a series of 10 steps but those DC voltages can correspond to any physical measurement, as noted above. The voltage steps to light each subsequent LED can be equal, meaning that the display is linear, or the steps can be non-linear, for example, giving a logarithmic display. In that case, each step could amount to say a 3dB increment.

It's easy to build this bargraph with a linear, logarithmic or any other scale since the steps are determined by a set of resistors, connected in series. We provide examples of the resistors to use for linear, logarithmic or VU (audio level) scales.

Alternatively, you could produce your own custom scale by using a different set of resistors.

This project is presented on two PCBs. One is the LED Dot/Bar display PCB and the other is the optional Signal Processing PCB, which is used to convert an AC signal into a suitable DC voltage to drive the bargraph.

All the components used on both boards are readily available. The main integrated circuits are LM358 dual op amps, two LM324 quad op amps and one LP2951 voltage regulator with most of the remaining components being resistors and capacitors. The LEDs that form the bargraph itself can be surface-mount types that sit directly on the PCB, or standard 3mm LEDs.

The LEDs will light up singly in dot mode or in a column of LEDs will light up in bargraph mode.

The display mode is selected by bridging pairs of solder pads on the PCB, with nine links (bridges) to solder for each mode. Once you've built the unit, it is configured as either a dot or bar display and this can't easily be changed later.

By JOHN CLARKE

Why not use an LM3914/5/6?

No doubt some readers are already thinking, "Why do we need all these comparators when single chip bar-

really flexible display options

graph ICs from National Semiconductor can already do this?"

The National Semiconductor LM3914 (linear) LM3915 (logarithmic) and LM3916 (VU) bargraph ICs certainly can do these jobs and they have been very widely used for many years.

However, the LM3915 has not been manufactured by National Semiconductor for 15 years and although we are aware that are still dribs and drabs around from some sources, NS advise not to base any new designs on this chip. So we won't!

Its cousin, the LM3916, was discontinued many years ago and is effectively no longer available. The only one that seems to be readily available in large quantities is the LM3914 – but the problem with this is that it can only display a linear scale.

And while these three bargraph ICs present an easy single-chip solution for many dot/bargraph applications, they do have limitations when you want to customise the circuit parameters.

For example, the LM3914 linear bargraph will always have an overlap in the transition from one LED to the next. That means that at least one LED is always illuminated but it does reduce the precision of the display.

In the case of the logarithmic LM3915, the LED step increments are fixed at 3dB, giving a 30dB range. You cannot change the size of the steps to 2dB, or less, for example.

And for both chips working in bargraph mode, all the illuminated LEDs are effectively in parallel and that can cause heat dissipation problems in the chips; they have limited power handling.

Indeed, for many audio signal bargraph applications, the circuit we present in this article is far more useful.

This is particularly the case in audio mixers where multiple LED bargraphs are required, with a resultant high current requirement. In those cases, the LM3914/5/6 series is definitely not ideal.

Yes, our 10-LED bargraph does use more components than the single-chip chip circuits but all the components are cheap and readily available and you can customise the circuit to suit your particular application, something that is not easy to do with the chip circuits.

Finally, these two boards provide a useful aid to demonstrate the use of op amps as comparators, window comparators, driving LEDs, along with signal metering and overall bargraph design.

Features & specifications

- 10 LEDs – you decide which type, colour, etc
- Dot or Bar modes
- DC or AC input voltages
- Linear, Logarithmic, VU or PPM display
- Runs from 12V (100mA maximum)
- Full-scale signal range adjustable from 583mV to 55V
- Uses readily-available components
- Suits surface-mount or through-hole LEDs

How it works

The 10-LED Bargraph circuit comprises ten op amps (operational amplifiers) that are used as comparators. Each drives one of the LEDs, switching it on when the input voltage exceeds (or drops below) a set threshold.

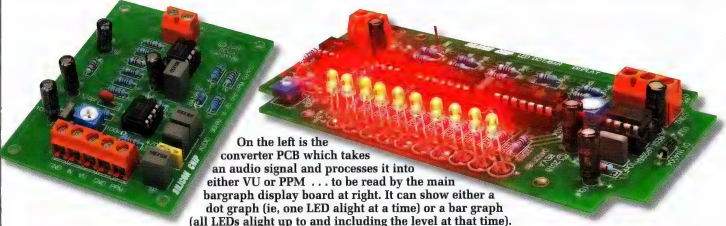
To begin, let's consider Fig.1, which shows a single op amp (IC2a) connected as a comparator to drive a LED.

The op amp's inverting input (-) pin 2 is connected to the input signal while the non-inverting input (+) pin 3 is connected to a voltage divider comprising resistors R1 and R2, connected in series between a reference voltage (V_{ref}) and ground.

Assuming that these resistors are the same value, the junction of R1 and R2 is one half of V_{ref} (ie, $V_{ref}/2$). So pin 3 of IC2a is held at $V_{ref}/2$. Now if the input signal at pin 2 is lower than $V_{ref}/2$, the output of IC2a will be high. But if the input signal at pin 2 is greater than $V_{ref}/2$, the output of IC2a will be low (at close to 0V).

That means that the op amp will pull current through the LED to light it up.

Note that we could use a comparator (such as the LM339) do this same function but if we wanted to reverse the action of the comparator, to drive a LED connected between its output and the 0V rail, it would not work



On the left is the converter PCB which takes an audio signal and processes it into either VU or PPM . . . to be read by the main bargraph display board at right. It can show either a dot graph (ie, one LED alight at a time) or a bar graph (all LEDs alight up to and including the level at that time).

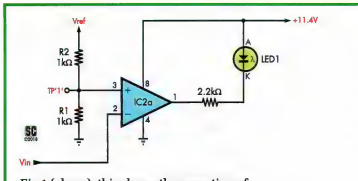


Fig.1 (above): this shows the operation of a comparator. It compares the input signal with a reference at its non-inverting input and turns on the LED if the input is above the reference.

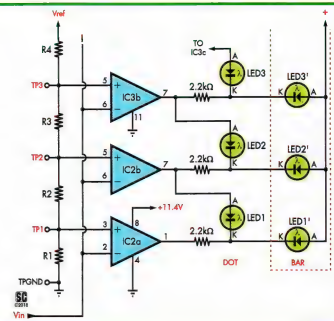


Fig.2 (right): this combines three comparators, each with separate reference voltages at TP1, TP2 and TP3. Each comparator will turn on its respective LED if the input voltage is above its reference voltage. The different LED connections provide for dot or bar modes.

since that type of comparator can only "sink" current rather than "source" it.

So we use op amps throughout out circuit because their push-pull outputs make them more flexible.

So now we want to drive more LEDs. For that, we add more comparators or in this case, op amps.

Fig.2 shows a triple comparator set-up, with each comparator driving one LED and with its non-inverting input connected to a resistor higher in the series string. The inverting inputs are connected together to monitor the same signal (V_{IN}).

Note that while we will refer to comparators in this article, in each case they will actually be op amps.

In fact, consider that op amps and comparator ICs contain almost identical circuitry; the main difference, besides the output configuration, is that op amps are compensated for closed-loop stability, which makes them slower to react. But for this project, we're dealing with slowly changing signals so that isn't a problem.

(Op amps are normally configured with external negative feedback while comparators normally have positive feedback [hysteresis]).

Fig.2 also shows the LED connections for the dot and bar modes. In bar mode, each LED connects between the positive supply and the op amp output via a series 2.2kΩ resistor. This means each LED will light whenever its comparator output is low.

For dot mode, the anode of each LED connects to the next higher op amp output. So a LED will light when the higher op amp output is high and the lower op amp output is low.

For example, for LED1, when Vin is higher than the voltage at TP1 but lower than the voltage at TP2, the output of IC2a will go low and current will flow from the output of IC2b, through LED1 and the 2.2kΩ resistor and then into the output of IC2a.

In other words, IC2b is "sourcing" LED1's current while IC2a is acting as the "current sink". As stated above, this would not work with a typical (open-collector output) comparator.

OK. Now when the voltage at Vin goes above the voltage at TP2 but is still lower than at TP3, IC2b's output will go low, switching off LED1 but it will sink current through LED2 which ultimately comes from the output of IC3b.

Therefore, in dot mode, only one LED will light at any given time.

For bargraph mode, the LEDs are reconfigured as shown in Fig.2 (LED1', LED2' etc) and so they will light up whenever the associated comparator output goes low, so if LED2' is lit, LED1' will be lit and if LED3' is lit then LED2' and LED1' will also be lit.

Switching thresholds and dithering LEDs

Having said that, it is possible for two LEDs to be alight (or partly alight) when the input signal is close to one of the voltage thresholds, defined by the reference resistor "ladder" (ie, at TP1, TP2, etc).

This is due to the fact that the op amps have inherent noise which can cause them to rapidly switch on and off when the two input voltages are very close together.

This can be prevented by using hysteresis and as mentioned above, this involves adding positive feedback between the output of each comparator and its non-inverting input.

However, that would require the addition of three resistors to each (op amp) comparator and we have not done that with this 10-LED bargraph circuit since it would mean an additional 30 resistors.

That's a lot of hassle to solve a minor problem.

Full circuit description

Now let's have a look at the full circuit of the 10-LED dot/bargraph display in Fig.3. This shows the 10 (op amp) comparators and the 10-resistor ladder network providing the reference voltage for each comparator.

The resistor network is connected to the output of adjustable voltage regulator REG1, an LP2951. This ensures a stable voltage to the resistor string regardless of variations in the input supply voltage. REG1's output voltage is adjusted by trimpot VR2 to a precise 10V DC.

Note that this bargraph circuit by itself is only suitable with a DC input signal; it will not respond an audio (AC) input signal. In this respect, it is the same as bargraph circuits using the LM3914/15 series chips. (We will get to the additional circuitry which

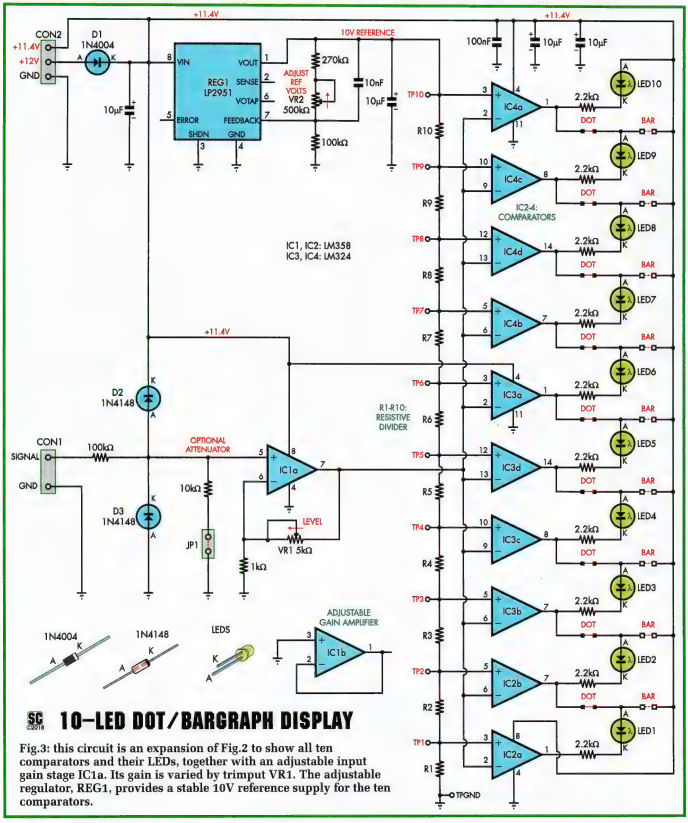
allows that later.)

The DC input signal is applied to CON1 and voltage is limited by the clamping diodes D2 and D3, to a range of 0-11.4V, protecting the circuit from excessive voltages. The input 100kΩ resistor limits the current through the D2 and D3 to safe levels.

If the input voltage to be monitored swings by more than 10V, it should be attenuated and that can be done by installing link JP1. That places a 10kΩ resistor in circuit which, in conjunction with the input 100kΩ resistor following CON1, attenuates the signal by a factor of 11.

Op amp IC1a is configured as a non-inverting amplifier with is gain varied by trimpot VR1. Its gain can be varied between unity (one) and six.

Note that op amp IC1b (part of the



10–LED DOT/BARGRAPH DISPLAY

Fig.3: this circuit is an expansion of Fig.2 to show all ten comparators and their LEDs, together with an adjustable input gain stage IC1a. Its gain is varied by trimput VR1. The adjustable regulator, REG1, provides a stable 10V reference supply for the ten comparators.

same dual op amp) is not used in the circuit and it is disabled by having it pins 1 & 2 connected together and pin 3 connected to 0V (GND), so it won't oscillate or otherwise misbehave.

The circuit is set for dot or bar modes by installing the soldering the appropriate set of PCB copper pads at the output of each op amp comparator, ie, either all the "DOT" pad pairs are joined or all the "BAR" pad pairs are joined.

The operation is then as described above, only with ten LEDs rather than three.

Handling audio signals

If you connected an audio signal up to CON1, half of it would be clipped by D3 and the other half would cause the bargraph to swing up and down rapidly; not really an ideal situation.

A better solution is to amplify, rectify and filter the audio signal to produce a DC level corresponding its peak or average amplitude.

There are many different ways of doing this, two of which are known as VU Meter or Peak Program Meter (PPM) displays. Further signal processing is required to achieve these responses.

All these possibilities are covered by the Signal Processing circuit shown in Fig.4.

It consists of a non-inverting amplification stage (IC5a), a precision full-wave signal rectifier (IC6a & IC6b) and a VU response filter stage (IC5b). IC5 & IC6 are LMC6482AIN dual rail-to-rail op amps.

The audio input signal from CON1 is fed via a 100nF capacitor and applied to potentiometer VR3. Instead of being directly grounded, the "cold" side of VR3 is connected to a voltage divider comprising two 10kΩ resistors, with the junction bypassed with a 100µF capacitor.

This method of connection allows the incoming signal to swing symmetrically about the half supply point (around 5.7V, ie, 11.4V÷2).

Op amp IC5a amplifies the attenuated signal by a factor of 16, giving a gain range of 0-16. Gain is reduced by frequencies above 32kHz due to the 330pF capacitor across the 15kΩ negative feedback resistor.

Its low-frequency response rolls off below 16Hz, as set by the 1kΩ resistor and 10µF capacitor between the inverting input (pin 2) and ground (0V).

Precision rectification without diodes

The output signal from IC5a is fed via a 10µF capacitor to the precision full wave rectifier comprising IC6a and IC6b. Its job is to convert the negative voltage portions of the signal into positive voltages so that we can determine the average signal level (the average of a symmetrical AC waveform is 0V).

This precision rectifier is unusual in that it does not use any diodes and nor does it need a negative supply rail. It works because the op amps are rail-to-rail types. This means that while their inputs and outputs can swing from within a few millivolts from +11.4V (ie, the positive supply rail) to 0V (or actually to -0.3V in the case of the input), if the input signal swings negative, the op amp's output will swing down to 0V but go no further.

So if we apply a sinewave centred about 0V to the input of voltage follower IC6a, its output will precisely follow the input signal for the positive excursion of the signal but the negative excursions will result in a 0V ("clipped") output. This means that the output signal at pin 1 will be a half-wave rectified sinewave.

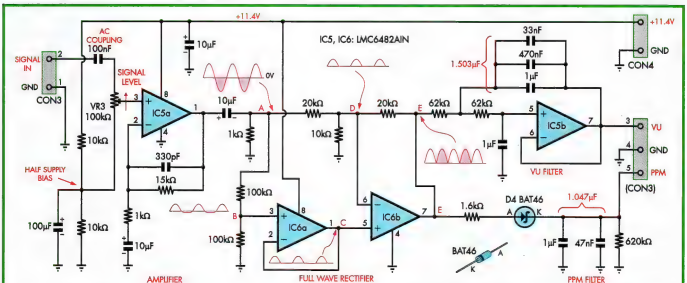
So that gives us a positive-going signal but only for the positive half of the AC signal. We need the whole thing. This is provided by IC6b and the way it works is very clever.

When the input signal at "A" is below 0V, the output of IC6a (at "C") is 0V as described above and thus the non-inverting input pin 5 of IC6b is at 0V; so it is grounded. It now becomes an inverting amplifier with a gain of -1, as determined by the two 20kΩ resistors at pin 6, one from the output at pin 7 and one from the input signal, at "A".

The third 10kΩ resistor is irrelevant since with an inverting amplifier, both inputs are at 0V and therefore that resistor will have 0V at both ends, so no current will flow through it. It's effectively out of circuit when the input signal is negative.

So IC6b will invert the negative-going signal at point "A" to an identical but inverted positive voltage signal at pin 7 ("E").

But when the input signal swings



SC CIRCUITS VU AND PPM CONVERTER

Fig.4: as an audio signal is AC, this circuit provides both rectification and signal filtering to give either VU and PPM characteristics. Its outputs drive the circuit of Fig.3.

positive, the output of IC6a at "C" will be identical to the input signal but with half the amplitude, because of the resistive divider at its input (pin 3).

Here's where it gets a bit tricky. Op amps use negative feedback to attempt to keep both their input pins at the same voltage. We have half the input voltage at pin 5 of IC6b, so we would expect to also see half the input voltage at pin 6.

The question then is what output voltage from IC6b is required to provide this. We have the full input signal at "A", which then flows through a 20kΩ resistor to "D".

If we assume that the output of IC6b is identical to the input signal (ie, the signal at "E" is equal to the signal at "A") then we can consider the two 20kΩ resistors to be in parallel, meaning the current is effectively flowing through a single 10kΩ resistor.

This virtual resistor forms a voltage divider with the 10kΩ resistor from "D" to ground, reducing the signal amplitude by half.

This matches the signal that's already present at "C", hence, this is the condition which will keep both op amp input voltages equal.

And that means that for positive voltages at "A", the output at "E" must be an identical signal.

Since we've just demonstrated that the output at "E" is identical to the input at "A" for positive voltages and an exact, inverted version for negative voltages, that means that the signal at "E" must be a rectified version of the signal at "A".

We have attempted to illustrate this rectification process with the waveforms at the various circuit points. So there is an sinewave shown at point A and resulting half-wave rectified signal with positive half cycles at points B, C & D. Note the periods for which points B & C and therefore pin 5 is held at 0V.

We have shaded the negative-going portions of the signal at point "A". These portions are effectively ignored by IC6a because it cannot respond to them.

But note the complete rectified waveform at point E. See that it includes the shaded portions of the signal which have been inverted and amplified by IC6b.

Filtering and processing

We now need to filter that rectified signal to recover a DC voltage that's proportional to either the peak of the incoming signal or the average, or some combination of the two with differing time constants (ie, VU or PPM).

VU metering was originally provided by a mechanical meter with particular physical characteristics which determined its response to signals.

It is not ideal for indicating transient signals that can cause amplifier clipping or excessive recording levels. However, the display is good for a general guide to signal levels.

The electronic VU filter built around op amp IC5b simulates the ballistics of a mechanical VU meter which is relatively slow responding to changes in level.

It is specified that upon a step change in the input level, it must reach 99% deflection in 300ms with a 1-1.5% maximum overshoot. This requires a second-order low pass filter with a high-frequency roll-off at 2.1Hz and with a Q of 0.62.

IC5b is configured as a Sallen-Key filter with the above characteristics, to produce the VU output at pin 3 of CON3.

If you're recording audio and you're

What do "VU" and a "PPM" stand for – and what do they measure?

Just about everyone would have seen (or at least seen a picture of!) a meter on an amplifier or tape recorder labelled "VU" with a scale running from -20 to +3, so it's a reasonable assumption that it is displaying "VUs", whatever they are! The VU – which, incidentally, stands for Volume Unit – is arguably the most misunderstood "measurement" (along with the decibel!) in the whole of electronics.

Peak Program Meters, or PPMs, probably run a close second. We'll get to those in a moment.

What is a Volume Unit?

Even though the VU meters found in a lot of consumer equipment are not particularly accurate (many are there more for show than anything!), the Volume Unit is actually an accurately defined quantity. It was first developed in the USA in 1939 by Bell Labs, along with broadcasters CBS and NBC, to show the "perceived loudness" of an audio signal. It became a US (and later international) standard in 1942.

The standard states that a reading of 0VU equals 1.228V RMS at 1000Hz across a 600 ohm resistance. Confused? Don't be: just remember that the VU meter is normally used to provide a quick visual guide, not give a definitive measurement.

Mechanical VU meters are slow to react to changes in level – deliberately so. This is partly due to the inertia of the meter itself (or ballistics) but also due to the circuitry around it; in effect the VU meter integrates the signal, presenting an average level rather than an instantaneous (or peak) level.

The whole point of a VU meter is to show a level which the circuit as a whole can handle without overloading (causing distortion). That's normally a level of 0 (zero) VU (on many VU meters this will also be shown as 100%).

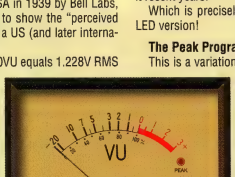
Above that (usually marked by a red zone on mechanical VU meters) you run the risk of overload – especially, for example, when you're recording to an analog tape recorder. That's why you adjust the level so that the reading seldom, if ever, goes much over 0VU.

Incidentally, VU meters and signals with lots of sharp transients (eg, drums) do not work well together – so much so that the VU meter, especially the mechanical variety, has fallen out of favour it recent years.

Which is precisely why we are presenting our highly flexible LED version!

The Peak Program Meter

This is a variation on the VU meter which shows, as its name suggests, the "peak" (or maximum) signal level. Again, this is designed to stop you over-driving a circuit or a recorder.



The PPM is often just a single LED which flashes on maximum level. If you set a level where the LED is mostly on, you will undoubtedly get a distorted signal.

Sometimes a VU meter will also incorporate a LED (as seen in the photo at left) to give this indication.

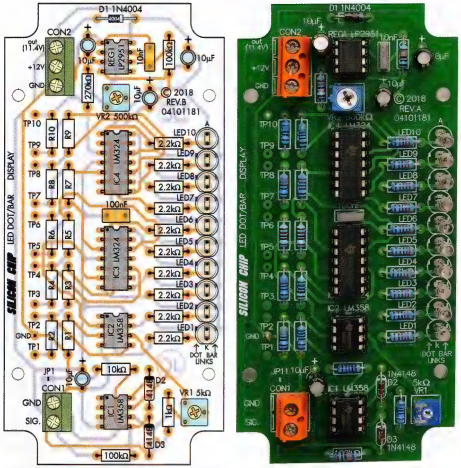


Fig.5: here's how to assemble the LED display PCB which is shown here with a matching same-size photo. Make sure you connect the bar *or* dot pads (*not both!*) on the underside of the PCB.

concerned about clipping (ie, the recording level exceeding the capability of the recorder to cleanly reproduce it), you are better off using a Peak Program Meter (PPM) indicator.

A PPM meter is built using a filter which ignores very short transients but otherwise has a fast attack and slow decay, so you can better see the peak level.

Its response should be 1dB down from the peak level for 10ms tone bursts and 4dB down for 3ms tone bursts.

These requirements are met by a filter with an attack time constant of 1.7ms and a 650ms decay rate.

Here we use a schottky diode (D4) to charge the 1.047µF capacitance (ie, 1µF and 47nF in parallel) via a 1.6kΩ resistor, which sets the attack time constant. The decay rate is set by the combination of the above capacitance and the parallel 620kΩ discharge resistor.

Construction

The 10-LED Bargraph is constructed on a PCB coded 04101181 and measuring 58 x 122mm. It fits into an optional UB3 plastic utility box measuring 130 x 68 x 44mm. Follow the overlay diagram of Fig.5 to see how each component is soldered to the PCB.

Before construction, decide whether you want a dot or bar display and whether you need a linear, log or VU scale. Use Table 1 to select the values of resistors R1-R10, according to your scale requirement.

Fit the resistors first. You can check the colour code for each resistor value by referring to the resistor colour code table but we recommended that you also check each resistor value with a digital multimeter before soldering.

Resistors are not polarised but it is a good idea to install them so that their colour codes all run in the same direction. This makes it so much easier to check their values later on.

Dot or Bar mode selection

If you want a dot display (ie, only one LED lit at a time), each pair of pads labelled "DOT" will need to be bridged with solder. There are nine such pairs. The dot links are on the underside of the PCB, between the end of the 2.2kΩ resistor and the LED anode.

Conversely, if you want a bargraph (where all LEDs will light on full scale), then bridge the Bar links located near the PCB edge (there are nine of these, too).

You may need to use short bits of resistor lead offcuts to bridge the two PCB pads if you find you can't do it with solder alone.

Having done that, install the capacitors. There are two types used in the circuit.

One type is MKT polyester and can be recognised by their rectangular prism shape and plastic coating. The second are electrolytic and are cylindrical in shape and have a polarity stripe along one side for the negative lead (the positive lead is also longer than the negative lead).

The electrolytic capacitors must be inserted with the correct polarity as shown on the PCB overlay, with the longer lead to the + side and the negative stripe on the opposite side.

Electrolytic capacitors will have their value and voltage rating printed on them while MKTs are marked with a code indicating their capacitance, shown in the capacitor codes table.

Now install diodes D1, D2 and D3; D1 is a 1N4004 (1A) type while D2 and D3 are 1N4148s (signal diodes).

You can then solder a single PC stake at the GND terminal position. This allows you to use an alligator clip lead to connect the negative probe of a meter to the circuit, while the positive lead with a standard needle probe can be used to contact test points TP1-TP10.

IC sockets for IC1-IC4 and REG1 should then be installed with the notched end towards pin 1.

Scale:	Linear	Log	VU
R10	1kΩ	6.8kΩ	1.1kΩ
R9	1kΩ	4.7kΩ	1kΩ
R8	1kΩ	3.3kΩ	820Ω
R7	1kΩ	2.2kΩ	750Ω
R6	1kΩ	1.6kΩ	1.3kΩ
R5	1kΩ	1.2kΩ	1kΩ
R4	1kΩ	820Ω	820Ω
R3	1kΩ	560Ω	910Ω
R2	1kΩ	430Ω	1.5kΩ
R1	1kΩ	1kΩ	680Ω

Table 1 – Values for resistors R1-R10.

Here's the area of the main PCB where you select the dot or bar graph mode (right under the LEDs). Simply short out the appropriate pads, as indicated. If you can't get solder to bridge across the gaps, use short lengths of resistor lead offcuts.

Before soldering, check that all the pins have gone through the holes in the PCB and that none are bent under the socket.

Terminal blocks CON1 and CON2 must be fitted with the wire entry holes to the nearest edge of the PCB.

Trimpots VR1 and VR2 can then be installed. VR1 is a 5kΩ trimpot that may be marked as 503 instead of 5k. Similarly, VR2 may be marked as 504 instead of 500k. Don't get them mixed up.

Now for the LEDs: if using surface mount LEDs, these are soldered in place on the top of the PCB with the anode of each toward the top of the PCB.

Use a multimeter set to diode test to check which is the anode and the cathode on each LED. The LED will glow when the red positive lead is on the anode (A) and the black negative lead on the cathode (k).

If using leaded LEDs, then the longer lead is the anode. Install these at an equal height above the PCB, which is most easily done using a spacer between the legs to set the height during soldering.

Now straighten the IC leads and insert them into their IC sockets, making sure that REG1 is not mixed up with IC1/IC2 and that each is oriented correctly, ie, pin 1 notch/dot lined up with the socket notches, as shown.

Signal processing board assembly

You only need to build this board if you are feeding an audio signal into the LED Bargraph. The PCB is coded 04101182 and measures 58 x 81mm. It can be stacked below the 10-LED Bargraph on 15mm standoffs if required. The overlay diagram is shown in Fig.6.

As before, solder the resistors first,

Parts list –10-LED Bar/Dot Graph

1 double-sided PCB, coded 04101181, 58 x 122mm
1 UB3 plastic utility box 130 x 68 x 44mm (optional)
2 14-pin DIL IC sockets
3 8-pin DIL IC sockets
1 2-way PCB-mount screw terminal (5/5.08mm spacing) (CON1)
1 3-way PCB-mount screw terminal (5/5.08mm spacing) (CON2)
1 PC stake
1 5kΩ mini horizontal trimpot (VR1)
1 500kΩ mini horizontal trimpot (VR2)
1 10kΩ 16mm linear potentiometer (for testing purposes)

Semiconductors
2 LM358 dual op amps (IC1,IC2)
2 LM324 quad op amps (IC3,IC4)
1 LP2951 adjustable regulator (REG1)
1 1N4004 1A diode (D1)
2 1N4148 small signal diodes (D2,D3)
10 3mm or SMD 1206 LEDs (LED1-LED10)

Capacitors
4 10μF 16V PC electrolytic
1 100nF 63V/100V MKT polyester
1 10nF 63V/100V MKT polyester

Resistors (all 0.25W, 1%)

1 270kΩ	2 100kΩ	1 10kΩ	10 2.2kΩ	1 1kΩ

For linear scale, add:
10 1kΩ (R1-R10)

For log scale, add:

1 6.8kΩ	1 4.7kΩ	1 3.3kΩ	1 2.2kΩ	1 1.6kΩ
1 1.2kΩ	1 820Ω	1 560Ω	1 430Ω	1 1kΩ

For VU scale, add:

1 1.1kΩ	2 1kΩ	2 820Ω	1 750Ω	1 1.3kΩ
1 910Ω	1 1.5kΩ	1 680Ω		

Parts for Signal Processing board

1 double-sided PCB, coded 04101182, 58 x 81mm
2 14-pin DIL IC sockets
2 2-way PCB-mount screw terminals (5/5.08mm spacing) (CON3,CON4)
1 3-way PCB-mount screw terminal (5/5.08mm spacing) (CON3)
1 100kΩ mini horizontal trimpot (VR3)

Semiconductors
2 LMC6482AIN CMOS dual op amps (IC5,IC6)
1 BAT46 diode (D4)

Capacitors
1 100μF 16V PC electrolytic
3 10μF 16V PC electrolytic
3 1μF 63V/100V MKT polyester
1 470nF 63V/100V MKT polyester
1 100nF 63V/100V MKT polyester
1 47nF 63V/100V MKT polyester
1 33nF 63V/100V MKT polyester
1 330pF ceramic

Resistors (all 0.25W, 1%)

1 620kΩ	2 100kΩ	2 62kΩ	2 20kΩ	1 15kΩ
3 10kΩ	1 1.6kΩ	2 1kΩ		

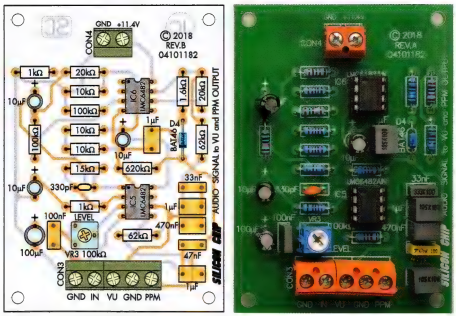


Fig.6: same-size PCB overlay and matching photo of the audio signal processor board, which drives the main display PCB in either VU or PPM modes.

then the sole diode (D4), then the capacitors.

Note that along with the MKT and electrolytic capacitors, this board also uses a ceramic capacitor, which will normally look like a disc and is not polarised. Then fit the IC sockets for IC5 & IC6, as before, making sure the notched end goes towards the pin 1 dot as shown in Fig.6.

Follow with trimpot VR3, which may be marked as 104 rather than 100k. Then install terminal blocks CON3 and CON4, again with their wire entry holes towards the closest edge of the PCB. CON3 is made by dovetailing a 3-way and 2-way screw connector together before inserting them into the board and soldering the pins.

Finally, insert the two ICs into their sockets, making sure that they are both oriented correctly.

Testing and setting up

Before powering up, check your construction carefully and in particular, check the orientation of the ICs and electrolytic capacitors and diodes. Is it a good idea to test the LED Bargraph PCB by itself first, even if you are going to use the Signal Processing board later.

Use a 10kΩ linear potentiometer connected as shown in Fig.7 for testing. Connect the power supply between the +12V and GND inputs but do not switch it on yet. Adjust VR2 so that the voltage between TP10 and GND is 10V and rotate VR1 fully anticlockwise for minimum gain from IC1a.

Switch on power and the LEDs should all light when the test potentiometer is rotated near fully clockwise and they should all be off when it is fully anticlockwise. LEDs should sequentially light up as the potentiometer is rotated clockwise, one at a time if dot mode was selected or in a bar otherwise.

You can check that the reference voltages are correct at test points TP1 to TP10. Table 2 shows the voltages expected at these test points for a 10V reference at TP10. The voltages should be within about 10% of the shown value in the table.

As you wind VR2 fully anticlockwise, you will find that the top LED will light with only about half full clockwise rotation. That is because the reference voltage for the LED Bargraph is below 5V and so the output from the potentiometer only needs to be this high for the top LED to light.

Similarly, if VR1 is rotated fully clockwise to amplify the potentiometer signal by about a factor of four, the amount of travel required from the potentiometer for a full-scale display will be small.

It will be around one-eighth of full rotation in a clockwise direction from an initial fully anticlockwise setting.

If you're using the Signal Processing board and the LED Bargraph board has

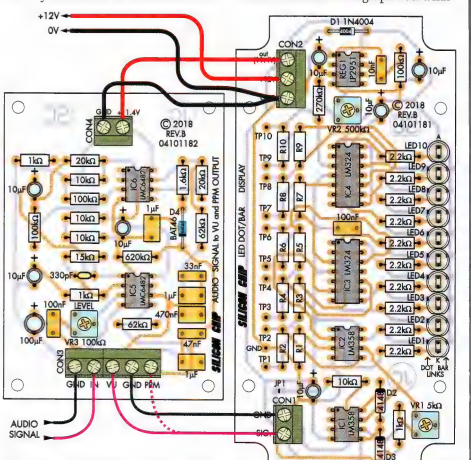


Fig.7: connections between the audio signal processor PCB (left) and the LED display PCB.

checked out so far, you can now wire the two together as shown in Fig.8. To calibrate it, apply a 250mV RMS audio signal to the signal input and set VR3 fully clockwise. Adjust VR2 for 10V at TP10 and adjust VR1 so the display just lights LED10.

You can then apply a line level audio signal to the input to see the display vary. Note that VR3 will need to be adjusted to reduce the line level voltage to a suitable level for monitoring on the bargraph.

Line level signals can vary over a wide range, from around 315mV RMS full scale up to 1.228V RMS, with some devices such as CD, DVD and Blu-ray players producing in excess of 2V RMS.

To make an accurate VU meter, the 0VU level (LED7) should be set to light with a 1.228V RMS signal applied to the audio signal input.

This level can be measured using a multimeter set to read AC Volts and a signal generator set to a frequency that the multimeter will measure accurately.

Typically, multimeters will accurately read 50Hz signals but some may measure above 1kHz. Check your meter's specifications before setting the signal generator frequency.

In practice, the sensitivity of the VU meter (or PPM) meter should be adjusted to set the range for the audio signal that's being monitored. SC

	Linear	Log	VU
TP10	10V	0dB (10V)	+3dB (10V)
TP9	9V	-3dB (7.08V)	+2dB (8.91V)
LED8, TP8	8V	-6dB (5.01V)	+1dB (7.94V)
LED7, TP7	7V	-9dB (3.55V)	0dB (7.08V)
LED6, TP6	6V	-12dB (2.51V)	-1dB (6.31V)
LED5, TP5	5V	-15dB (1.78V)	-3dB (5.01V)
LED4, TP4	4V	-18dB (1.26V)	-5dB (3.98V)
LED3, TP3	3V	-21dB (0.89V)	-7dB (3.16V)
LED2, TP2	2V	-24dB (0.63V)	-10dB (2.24V)
LED1, TP1	1V	-27dB (0.417V)	-20dB (0.71V)

Table 2 – Test point voltages/ signal thresholds.

Resistor Colour Codes

* Quantity depends on configuration – see parts list.

Qty	Value	4-Band Code (1%)	5-Band Code (1%)
*	620kΩ	blue red yellow brown	blue red black orange brown
*	270kΩ	red purple yellow brown	red purple black orange brown
*	100kΩ	brown black yellow brown	brown black black orange brown
*	62kΩ	blue red orange brown	blue red black red brown
*	20kΩ	red black orange brown	red black black red brown
*	15kΩ	brown green orange brown	brown green black red brown
*	10kΩ	brown black orange brown	brown black black red brown
*	6.8kΩ	blue grey red brown	blue grey black brown brown
*	4.7kΩ	yellow purple red brown	yellow purple black brown brown
*	3.3kΩ	orange orange red brown	orange orange black brown brown
*	2.2kΩ	red red red brown	red red black brown brown
*	1.6kΩ	brown blue red brown	brown blue black brown brown
*	1.5kΩ	brown green red brown	brown green black brown brown
*	1.3kΩ	brown orange red brown	brown orange black brown brown
*	1.2kΩ	brown red red brown	brown redblack brown brown
*	1.1kΩ	brown brown red brown	brown brown black brown brown
*	1kΩ	brown black red brown	brown black black brown brown
*	910Ω	white brown brown brown	white brown black black brown
*	820Ω	grey red brown brown	grey red black black brown
*	750Ω	purple green brown brown	purple green black black brown
*	680Ω	blue grey brown brown	blue grey black black brown
*	620Ω	blue red brown brown	blue red black black brown
*	560Ω	green blue brown brown	green blue black black brown
*	430Ω	yellow orange brown brown	yellow orange black black brown

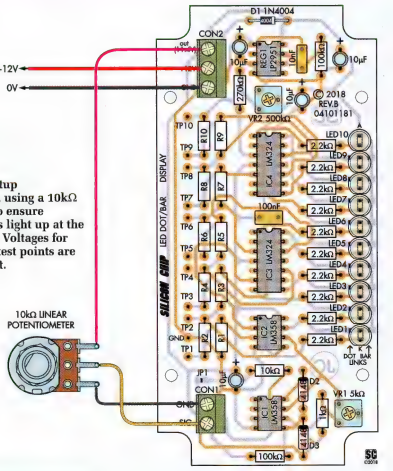


Fig.8: test setup connections, using a 10kΩ linear pot, to ensure that all LEDs light up at the right points. Voltages for the various test points are shown at left.

ALTRONICS

Build It Yourself Electronics Centre®

February

DEAL OF THE MONTH!

Add wireless sound to your kitchen, study or entertaining area.

Stream music directly from your phone or tablet with this Bluetooth hi-fi audio package. It combines our best selling pair of Opus One C 0873 6.5" ceiling speakers with the popular A 1115 2x20W Bluetooth amplifier. 20m range.

C 0873 + A 1115

$199

SAVE $169

Scoop purchase! Why pay $179?

$99

C 9037

$1199

NEW MODEL!

Nothing else to buy! Pre-installed with 1TB hard drive.

S 9941

$29.95

X 2375

NEW!

No headphone jack on your phone?

No worries! These new Jabees Shield 'true wireless' bluetooth earbuds are perfect for exercise - they're sweat resistant, light weight and provide 9hrs of listening time. Great alternative to Apple Airpods! Includes charging case and replacement earbuds.

4 Channel Wireless CCTV System

Add security to your home or business with our high resolution 4 megapixel (1080p) CCTV pack. Wireless cameras cut down installation time and effort! Pack includes power supplies for each camera, a network video recorder (expands to 9 channels!) and four compact bullet cameras.

Add light instantly!

A stylish motion activated light for paths, driveways, garden sheds etc. Charges by day, lights at night. Requires no batteries or cabling - just screw it to the wall in a sunny spot. Weatherproof design. 145W x 96L x 75Dmm.

SAVE $20

$89

D 2815

All your home entertainment in one box.

Stream direct to your TV from your favourite services such as Netflix, Stan, YouTube and more! Capable of streaming stunning 4K videos @ 60fps! Requires 2A USB power supply. Pair it with our A 0981 wireless keyboard/trackpad for $29.95.

USB Car Jumpstarter & 2-in-1 Floodlight

A must have for summer road trips! Starts most 4 & 6 cylinder cars from dead flat. • 300 cranking amps

- Fits in your glovebox
- High power LED flood light
- USB phone charging
- Suits 12V vehicles only.
- **Includes carry case, battery clips, mains charger & USB lead.**

M 8194

HALF PRICE!

$64.50

SAVE 22%

$35

Q 1224

Gas Bottle Level Detector

Keep tabs on how much gas you have left and avoid an embarrassing scene at your next BBQ! Requires 9V battery (S 4970B $3.95).

Add Bluetooth Audio Instantly!

Adds wireless audio streaming to any 3.5mm input, whether it be your car, your favourite headphones or home amplifier. Internal battery provides 5 hours of listening time and is USB rechargeable. Just 40mm long, weighing a mere 20g!

$29.95

A 1101

NEW!

High Definition 7" Monitor With TV Tuner

The perfect compact TV/ monitor for your car, 4WD or caravan! 7" wide format LCD features in-built HD tuner to receive all digital channels. AV input can be hooked up to a camera or AV source. USB PVR recording, MP3 & video USB/ SD playback. 12V or 240V operation (includes plugpack).

SAVE 20%

S 8861B 7"

$159

S 8861B 9"

$195

Plus dual USB charger!

$44.95

X 0604A

Bluetooth FM Audio Player

Transmits bluetooth audio from your phone (music, phone calls etc) to your cars FM radio.

SAVE $40

$79

X 6010

Project your dashboard onto your windscreen!

Keep your eyes on the road.

Suitable for any vehicle with an OBDII port, this easy to install head up display (HUD) allows you to keep your eyes on the road. It shows speed, RPM, fuel consumption, warning lights and more!

D 0505A 1A 4000mAh

$24.50

NEW!

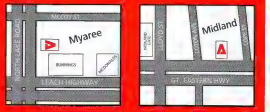
$33.95

D 0507A 2A 8000mAh

Super Slim Battery Banks

Instant recharge for your phone. Slimline aluminium design, fits easily in your pocket.

NEW stores now open in WA!



MYAREE

5A 116 North Lake Rd

MIDLAND

212 Gt Eastern Hwy

To find your nearest store, visit: www.altronics.com.au/storelocations

Sale pricing ends February 28th 2018.

Top choice for the enthusiast

100W Portable Gas Tool

Blow torch & soldering iron in one. Totally wireless operation. No need to run extension leads! Easy to light, one-click piezo ignition. 2 year warranty. Kit version includes hot air tip, heat deflector, additional gas cartridge, solder, sponge and hard carry case.

T 2598 Top Only **$60** SAVE 24%

T 2599 Kit **$109** SAVE $25

High Power Blow Torch

Super hot 1350°C flame! Handheld or self standing design for tasks such as heatshrinking, model making, silver soldering! Easily refilled. All aluminium design.

T 2494 **$55** SAVE $15

$189 T 2444A

SAVE $50

Whisk away those soldering fumes!

#1 choice for schools! This 60W soldering station has a powerful in-built fume exhaust fan which sucks away the smoke when soldering. The active filter helps to reduce airborne pollutants in your workshop. Durable metal construction.

Pocket Rocket Blow Torch

One tick of the trigger and you have a whooping 1300°C flame ready for blazing. Reliability gas cartridge.

$19 SAVE 15% T 2499

Iroda® Butane 4 Pack

Stock up the workbench with this value pack of quality double strubbed butane. Doesn't clog your tools like the cheap stuff.

4 for **$28** T 2451

SAVE 12%

Mini Jet Blowtorch

Produces a powerful jet like flame - up to 1300°C! Reliable design is great for hobbyist.

SAVE 20% T 2488 **$15**

Accurate to 2mm!

SAVE $19.95

$70 T 2252

Upgrade to laser measurement!

Don't grapple with a floppy tape measure for a minute longer. This accurate time saving device is great for trades & consultants. 30m max range. Requires 2 x AAA (S 4904 $4.95 4pk)

GIVE YOUR TOOL BOX SOME LOVE WITH THESE DEALS...

NEW!

Handy USB Soldering Iron

T 2699A **$16.95**

Powered by a USB port! Great for occasional jobs like fixing a dry joint. Built in handle switch and auto sleep mode ensures safe operation. Includes stand & USB lead.

$269 SAVE $60 Q 0207

Turn a laptop into a 25MHz scope!

The Velleman PCSU200 is a do-it-all solution to save space on your workbench and make use of your PC or laptop. It connects via USB and provides function generator, 25Mhz oscilloscope, transient recorder, bode plotter and spectrum analysing functions. Includes Windows software, USB cable & easy to read getting started guide. For full specs see our website.

$19.95 Q 1278A

Handy Probe Thermometer

Stainless steel easy clean probe. Great for use in the lab/kitchen. -50°C to +330°C

Finally a clamp meter designed for electronics!

Specialises in low current, high resolution readings down to 1mA. Suits AC or DC use up to 80A. Cat III 600V. 2 year warranty. Includes test probes for other multimeter functions.

Q 0968 **$140** SAVE $39

Superb quality for precision electronics use.

T 2749 **$44** SAVE 24%

Tungsten 5" Side Cutters

Ideal for cutting solid core steel, copper & piano wire. HRC72* hardened jaws provides 5 times the life of standard sidecutters.

$34.95 T 2162

'Getting Started' Electronics Kit

Great for enthusiasts and students. This handy kit is supplied complete with carry case and includes all you need to get soldering! • 30W soldering iron & stand • 2m solder • Solder sucker • Pliers & side cutters.

SAVE $40

T 2177 **$119**

Universal Crimping Tool Kit

Changes jaws in seconds! Includes 7 sets of magnetic jaws to suit kwik crimps, uninsulated lugs, telephone spades, shoelace ferrules, RG58, RG59 RG62, RG6 coax crimps and D-Sub connectors.

True RMS Autoranging Meter

A price breakthrough for accurate True RMS AC measurement! Packed with features for under $40. Includes carry bag and test leads.

$39.95 Q 1130B

Digital Vernier Calipers

Precision measuring with ease! 150mm length, suitable for measuring internal, external and depth dimensions. 0.01mm, 0.0005" and 1/128th" display.

$40 SAVE 27% T 2247A

SAVE 20%

40pc Ratchet Driver Kit

A great selection of bits and sockets and a quality ratchet driver with comfy rubberised grip.

$50 T 2168

Magnifier Head Goggles

Offers 1.5, 2.6 and 5.8x magnification with in-build LED lamp. Requires 2xAAA's (S4904 $4.95 2pk).

$30 T 2555

Shop online 24/7 @ www.altronics.com.au **1300 797 007**

GREAT POWER SAVINGS

$209
M 8200A
0-30V 3A

$245
M 8205
0-30V 5A

Linear Lab Power Supplies

Our most popular models! Fully adjustable with LCD meters for precision adjustments. Great for R&D and workshops. • Linear toroidal design • Voltage & current knobs • Fixed 12V & 5V output rails • Fully regulated • Short circuit & overload protection.

A 0309B

$30

25% OFF!

Stay powered up on your travels!

Pick up this great travel charger to keep up to 4 devices charged at once! Includes adaptors for Australian, US, UK and European outlets. 5V 4.1A output. 100-240V AC input. - Travel case included!

Device & charging leads not included

$119
M 8882

SAVE $40

Charge up to 10 USB devices at once!

Great for families, classrooms and businesses. Massive 19A charging output. Rapid charging 2.4A output on each port. Includes adjustable dividers & power supply.

$47
A 0287A

Also suits NiMH batteries

Lithium Cell Charger

With 5V USB output (use charged cells as a power bank). 12V DC car & mains use. Suits AAA/AA/C NiMH & 10340 to 26650 lithium.

Solar Battery Maintainer

Provides a trickle of power to your car, caravan or boat battery to keep it topped up when parked for long periods. 355x125mm panel size. Suits 12V batteries only.

N 0700

$20

SAVE 33%

$70

SAVE 25%

M 8528

Compact SLA Charger

Easy to use, with trickle charging function. Multi-stage charge control ensures long battery life. 6/12V batteries up to 60Ah

D 0875

$95

SAVE $14

UPS Backup for 12V DC Appliances

A compact 12V DC 18W UPS unit for providing backup power to all kinds of DC powered equipment. Great for routers, NAS, telephone & comms systems.

BIGGER, BETTER SOUND...

NEW!

$199

A 4201

Bluetooth® 2 x 50W Mini Amplifier

Stream audio directly from your device to your speakers in the study or entertaining area. 3.5mm and RCA inputs. Class D design. Internal headphone amplifier.

$299

C 5201

SAVE $100

Rattle the floorboards!

180W Subwoofer Sensation!

Add stunning cinema realism to your home theatre sound system. Massive 180W 10" driver with built in amplifier. Size: 490D x 315W x 420H. *Pictures without included cloth grille.

$239

C 0993
10" 180W

$175

C 0991
8" 100W

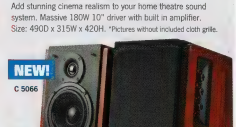
SAVE $60

Instant, powerful PA sound for big crowds!

An all in one portable PA sound system with amplifier that sets up in just seconds - no expertise required. Just plug into 240V power, switch it on and connect a mic. USB playback makes it easy to play your favourite tunes. Great for clubs, sports events, fetes, carnivals and bingo nights!

NEW!

C 5066



$249

Edifier® Active Bookshelf Speakers

With Bluetooth streaming. We were floored when we demo'ed these speakers! Great sound from a compact enclosure design. Fantastic sound for your home theatre, hi-fi or gaming rig. Dual analog RCA inputs. Model: R1700BT. Size: 154×258×214mm

$189

SAVE $60

A 3250

HDMI & IR Extender System

Extends 1080p signals up to 50m, plus bi-directional IR for control of equipment from both ends. Includes power supply, two IR targets, two IR emitters and facias to suit existing decor.

$199

SAVE $66

A 2651

Ideal for bands & small venues.

6 Channel Mixer With USB Player

Featuring USB/SD card playback with easy to use controls. All channels feature balanced XLR, unbalanced 6.35mm, insert inputs, high/mid/low adjustment, pan & gain level.

$38

SAVE 24%

Add Bluetooth audio to any amp.

Pairs with your phone to stream your favourite tunes to your existing sound system. Includes 3.5mm lead. Buy P 6020 1.5m lead ($6) to hook up to RCA input on most amps. USB 5V 1A charging output.

$20

A 1012

SAVE 33%

Replace a broken remote.

With IR learning and codes to suit 1000's of AV devices. Requires 2xAAA batteries.

SAVE 20%

H 8222A
Dual

$120

H 8220A
Single

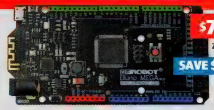
$80

Reclaim your desk space!

These stylish PC monitor brackets raise your monitor off your desk. Easily adjustable angle & height. Clamps to your desk for fast installation.

DESIGN, BUILD & MAKE FOR LESS.

Bluno M3 ARM Bluetooth Board
Integrates a Bluetooth 4.0 chip and a STM32 ARM controller on the board. Great for wireless programming or controlling a project with a phone.



Bluno Mega2560 Arduino Bluetooth Board
Integrates Bluetooth 4.0 into the Arduino Mega platform allowing wireless programming and real time low energy communication with your project.

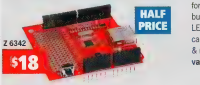
*Raspberry pi for illustration purposes.

3D Gesture Control For R-Pi
FlickHAT is a 3D tracking and gesture HAT that lets you control your Pi with a swipe, tap or flick your wrist. Detects gestures up to 15cm away in 3D space. Also works as a touch sensor pad.

Bluno Nano Arduino Bluetooth Board
The Bluno Nano offers a compact atmega328p platform with in-built Bluetooth 4.0 low energy for easy connectivity. Just 53x19mm in size - great for portable designs.

3 Wire Serial 128x64 LCD
Includes easy connection SPI interface module. Blue backlight with white characters.

Arduino Starter Platform Kit
A handy starter kit for educators or Arduino newbies. Includes an Arduino UNO compatible board, blue acrylic base, 5V 2A power supply, USB lead, breadboard, 65pcs of jumper leads & hardware.



USB Host Peripheral Shield
Connect USB peripherals & mass storage devices to your Arduino. Uses the MAX3421E chip.

USB Bootloader Programmer
Great for reprogramming your own atmega chips. Includes 6 and 10 pin cables.

Real Time Clock For R-Pi
Provides accurate time for the Raspberry Pi. Plugs into the I2C bus. Includes battery.

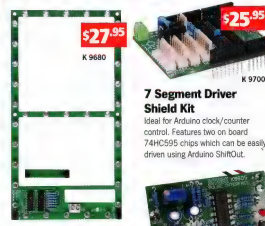
Tinker Part Pack
A huge assortment of parts for experimenting and building. Includes diodes, LEDs, switches, resistors, caps, strip board, a motor & more. **Normal RRP value $55!**

L298 H-Bridge Motor Shield
Uses an L298 H-Bridge designed to drive relays, solenoids, DC and stepping motors. It can also drive two DC motors. 5V input.

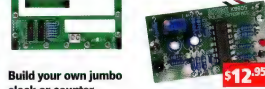
DIY Geek Tinkerers Kit For Arduino
Includes an Arduino UNO compatible board, proto-shield, alphanumeric LCD, dot matrix LED module, 7 segment displays, two breadboards, stepper motor, servo, IR remote, connection leads, battery box and a variety of components, buttons and sensors.

MegaStand Acrylic 16x2 LCD UNO Kit
A cut down MegaBox which provides a backlit 16x2 LCD for simple readouts, plus room to customise the front panel with buttons or IR sensor. UNO (sold separately) fits neatly behind the screen and provides room for add-on shields as required.

MegaBox Kit For Arduino
The MegaBox allows an Arduino UNO or Mega to be plugged into it, along with a shield allowing you to build a design into a finished case. Plus it also features a 16x2 LCD, four buttons, rotary encoder, dual 2A 5V relay outs. All pins broken out to headers for connection to breakouts.



7 Segment Driver Shield Kit
Ideal for Arduino clock/counter control. Features two on board 74HC595 chips which can be easily driven using Arduino ShiftOut.



Build your own jumbo clock or counter
This handy kit makes one 210x110mm digit and can be paired with additional digits to create a clock, number counter etc. Red high brightness LEDs. Driven by Arduino ShiftOut.

Heart Rate For Arduino Kit
(DIYODE Nov '17) A simple kit design for biometric Arduino projects - or anything where measuring a heartbeat is required. Requires 9V battery (S 4970B $3.95)

Simple Logic Probe Kit
(DIYODE Oct '17) A simple 3 state logic probe for diagnosing circuits, checking output pins etc. Includes test clip connection lead.

Sale Ends February 28th 2018
Phone: 1300 797 007 Fax: 1300 789 777
Mail Orders: mailorder@altronics.com.au

B 0091

Find your nearest reseller at:
www.altronics.com.au/resellers

Prices and specifications may change without notice. Limited stock on some items. Errors and omissions excepted. Trade discounts available on application. Prices include GST. Freight is extra. Please refer to our catalogue for freight rates.

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.

Vintage car logbook reminder with temperature and clock display

Like me, I would think many readers have a classic or historic car tucked away in their garage. Fortunately, most states in Australia have registration regimes that support these cars by way of substantially reduced registration fees.

However, there are restrictions on how many days you can drive in a year and in some states, only to specified events.

In all cases, a log book is required to be filled out for each day the vehicle is used on a public road. In Victoria, if a vehicle is on the road with no matching logbook entry, that can result in an $800 fine. So, it is rather important that the logbook is filled out. But this does require remembering to do so!

This project is specifically designed to assist those of us that are memory challenged by way of flashing a "FILL IN LOGBOOK" on a 16x2 LCD display when first powered up (ie, when the ignition is turned on). Briefly pushing the "program" button will clear this and the display will then show the current temperature in the car and time.

Subsequent powering up will not show the warning for that particular day, which would be annoying (especially if your classic car, ahem, finds itself by the side of the road quite frequently!) but it will warn again on the next day.

It does this by comparing the date from the real-time clock to the one stored in EEPROM from the last time the unit was powered up. If different it is assumed that one or more days have elapsed.

The circuit is straightforward and takes advantage of a low-cost alphanumeric LCD with I²C piggyback module (El Cheapo Modules, March 2017; **siliconchip.com.au/Article/10584**) and an Arduino-compatible battery-backed real-time clock module. Tying them all together is the venerable PICAXE-08M2.

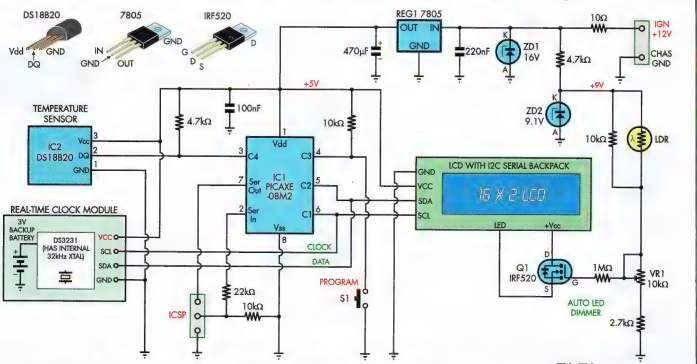
One issue of using an 8-pin micro like this is the lack of I/O pins – but I love a challenge. Since the LCD and real-time clock both use I²C, interfacing with both only takes two pins. Two further pins are used for the PICAXE power supply, two for programming and one for the D18B20 One-Wire digital temperature sensor.

That leaves just one pin for both clearing the warning and providing initial settings for the real-time clock. The later is achieved by carefully measuring how long the program button is pressed for.

This also has the advantage of making the final unit visually clean with just the LCD panel and one button needing to be mounted in the vehicle. I fitted both inside the ashtray holder of my Mini Moke.

This single button is used to perform a number of tasks. For example, holding it down for approximately four seconds puts the unit into setup mode. The unit will then cycle through the settings for the year, month, day, hour, minute, etc.

For each setting, the user has about



CLOCK & TEMPERATURE DISPLAY FOR VINTAGE CARS

Circuit Ideas Wanted

Got an interesting original circuit that you have cleverly devised? We need it and will pay good money to feature it in the Circuit Notebook pages. We can pay you by electronic funds transfer, cheque (what are they?) or direct to your PayPal account. Or you can use the funds to purchase anything from the SILICON CHIP on-line shop, including PCBs and components, back issues, subscriptions or whatever. Email your circuit and descriptive text to editor@siliconchip.com.au

one second to push the program button to increment the value shown.

Although the PICAXE-08M2 does not support edge-triggered input port interrupts and relies on polling routines to capture input changes, it works surprisingly well and setting the various values is easy.

The LCD's I²C interface breaks out the backlight LED connection to the onboard switching transistor (which is controlled by I²C commands). I've used these to provide a simple auto-dimming function.

This uses an extra Mosfet (Q1) with its gate biased by a resistor network incorporating an LDR. As the light level decreases, this automatically reduces the backlight LED current. VR1 allows the threshold to be adjusted.

You may need to tweak the resistor values shown to suit your LDR. Unfortunately, the dimming circuit requires a separate supply connection to bias Q1's gate into conduction but this is pretty simple to run along with the I²C wires.

The real-time clock module has an onboard backup battery so that the time and date are not lost when the ignition is switched off. Since this should last years, I haven't bothered to connect an unswitched 12V line to the unit from the vehicle's battery to maintain the time.

You could use a clock module with a rechargeable Li-Ion battery which would be topped up each time it's switched on. Otherwise, Consideration for access to change the lithium cell should be given when designing the hardware and mounting arrangement.

The power supply is fairly simple, using a 16V zener diode to filter out brief voltage spikes, in combination with a 10Ω current-limiting series resistor and then a 7805 linear regulator to produce the 5V required to run the LCD and PICAXE chip.

A second zener, ZD2 (9.1V) develops the gate bias voltage for Q1, using a 4.7kΩ current-limiting resistor as very little current is required for this purpose.

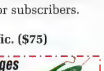
The supplied BASIC code is well-documented, particularly concerning exactly how to initialize the display via the I²C port expander and then using it in 4-bit mode.

This turns out to be fairly complex. Don't forget to change the I²C address for the LCD to suit the chip used in your unit. The program is named "Classic Car Temp and Date.bas" and is available for download from the SILICON CHIP website, free for subscribers.

Clive Allan,
Glen Waverley, Vic. ($75)

Fun for kids of all ages

KELVIN, THE *VERY* CLEVER CRICKET



See SILICON CHIP October 2017

Fun to build and fun to use: Kelvin can accurately tell the temperature and chirps it to you (in cricket code) while he flashes his eyes! You can build Kelvin in just an hour or so!

View online at siliconchip.com.au/Article/10828

Special pre-cut PCB plus programmed micro available from the SILICON CHIP online shop: www.siliconchip.com.au/Shop

PICAXE roulette wheel simulator using 7-segment displays

Build this PICAXE-based roulette wheel project and have all the fun of playing roulette in your own home without the risk of losing your shirt. It uses three 7-segment LED displays which makes it easy to build; so easy, in fact, that you could include multiple "wheels" in one rig.

A real roulette wheel is broken up into either 37 or 38 segments with numbers 0-36 (plus 00 on American wheels). While it spins, a ball is thrown so that it runs around the edge of the wheel in the opposite direction.

As the ball runs out of momentum, it drops into one of the wheel segments, selecting a number. Those who have bet on that number (or its colour) win extra chips while those who have not lose their chips.

This unit works slightly differently but it serves the same purpose, to spin the wheel and then randomly select one of the numbers on it.

Two 7-segment LED digits show the current number as the wheel "spins" and a third 7-segment display indicates the current colour: red (for 18 numbers), black (another 18) or green (0-2 numbers), with one segment lighting for each as shown on the circuit diagram.

When the spinning "stops", the number left on the display is the winner. Detailed information about all aspects of roulette can be found in books or on the internet.

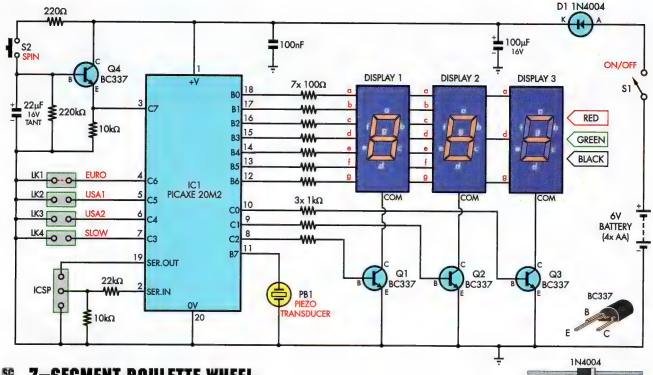
Note that you could replace the DISP3 with three discrete LEDs, however, you might have trouble finding a black LED!

PICAXE20M2 microcontroller IC1 drives the three 7-segment displays in a multiplexed manner. The three sets of eight anodes are wired up in parallel and driven from PICAXE output pins via 100Ω current-limiting resistors. The common cathodes are driven by three BC337 transistors, Q1-Q3, with 1kΩ base current limiting resistors.

There are four links (LK1-LK4) between PICAXE pins 4-7 and ground. Internal pull-ups are enabled on those inputs so that if a shunt is fitted, it pulls the corresponding pin to ground and IC1 can sense this.

LK1 selects European style Roulette with 37 segments (single zero). LK2 selects American style Roulette with 38 segments (including 0 and 00). LK3 selects a modified American style Roulette with 36 segments (no zeros). LK4 slows the operation down so that you can more closely observe the number sequence produced.

...continued next page



7-SEGMENT ROULETTE WHEEL

The numbers are in a different order depending on whether European or American style is selected but the colour assigned to each number is the same. The zeros are house numbers giving a guaranteed return to the casino so a wheel layout is included without zeros for use at home.

To spin the wheel, hold down S2 and the 22µF capacitor charges quickly via the 220Ω resistor. NPN emitter-follower transistor Q4 buffers the signal so that input pin 3 of IC1 goes high when this capacitor is charged.

Releasing S2 allows the 220kΩ resistor to slowly discharge the 22µF capacitor, until input pin 3 on IC1 returns to a low level and stops the numbers cycling.

IC1 pulses pin 11 high briefly to produce click sounds from piezo transducer PB1 as the wheel "spins".

When S2 is pressed a second time, the wheel starts spinning from the last number selected. How long it spins and thus which number it ends up on depends on how long the S2 button is held and the discharge time of the 22µF capacitor.

Power is from a 6V battery (eg, four AAs) and the circuit includes a power switch S1 and uses diode D1 to reduce the voltage to just over 5V while also providing reverse battery protection.

The prototype roulette wheel was housed in a circular container (because roulette wheels are round) but could also be housed in a rectangular jiffy box. The displays and controls should face upwards when on the table. The recommended common-cathode 7-segment displays are blue Jaycar Cat ZD1856. Alternatively, the less bright red Jaycar ZD1855 can be used.

The piezo transducer can be either Jaycar Cat AB3440 or Altronics Cat S6140.

The circuit includes an ICSP header to load programs into PICAXE microcontroller IC1 with pin 2 as the serial input and pin 19 as the serial output.

You need a PICAXE-compatible USB cable and the free "program editor software" from the PICAXE website to upload the BASIC code, which is available from the SILICON CHIP website ("roulette7seg_20m2.bas"), free for subscribers.

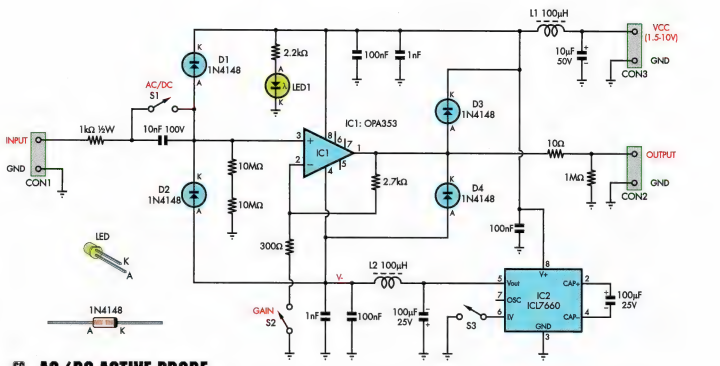
Ian Robertson,
Engadine, NSW. ($60)

Active probe uses switched capacitor charge pump

Sometimes when feeding a signal to a piece of test equipment, you need an active probe near the signal source to buffer or amplify the signal.

The reasons this can be necessary are numerous and include:

- The input impedance of the test equipment is too low, eg, lower than or close to the source impedance of the signal being measured. An active probe with a high input impedance and low output impedance can overcome this.
- To protect sensitive test equipment from voltage spikes or accidentally connecting the probe to a high voltage part of the circuit.
- To boost a very low-level signal so that the test equipment can register it, or to improve the signal-to-noise ratio. This is especially effective when a local ground point reference is used in the circuit as this can help overcome probe earth impedance/inductance effects.
- When the test probe needs to be soldered to the circuit being tested, to ensure a good connection or because there are no good points to clip it to, and the test equipment does not have solderable leads.
- When you need to remove the DC component of an AC signal, to feed it to equipment which does not have an AC-coupling option, or to apply gain to the AC portion of that signal without amplifying the DC portion.



AC/DC ACTIVE PROBE

More than one of the above could be true. In all cases, this active probe will help. It only requires a single positive supply voltage even for signals which may swing above and below ground.

The supply could be a DC plugpack, a 9V battery or even a USB port. The operating supply voltage range is 1.5-10V, with higher voltages giving better signal handling.

It's based on op amp IC1. This is an OPA353 which was chosen for its high bandwidth (44MHz), rail-to-rail input and output which maximises signal handling, low minimum operating voltage, low noise and very high input impedance. Other unity-gain stable op amps can be used but may not give equally good performance.

The input signal is fed through a 1kΩ 0.5W series resistor and then via either a 10nF AC-coupling capacitor or switch S1 to non-inverting input pin 3 of IC1. The 1kΩ series resistor, in combination with clamp diodes D1 and D2, protect IC1 from damage for signal voltages up to about 23V beyond its supply rails. With a 9V supply, that means it will not be damaged by signals up to ±32V.

The input impedance of the circuit is set to around 20MΩ by the two series 10MΩ resistors from pin 3 of IC1 to ground. With S1 closed, the signal is DC coupled and with it open, it is AC-coupled with a time constant of 20MΩ × 10nF = 200ms.

Voltage gain is selected using S2. With it closed, the gain is 1 + 2700Ω ÷ 300Ω = 10 times. With it open, the gain is one (unity, ie, no gain or loss).

Either way, the signal is applied to output connector CON3 via a 10Ω resistor which stops the capacitance of the equipment being fed (and the cabling) from destabilising op amp IC1.

A 1MΩ resistor across CON3 provides a path for output current to ground if the output is not connected, or is capacitively coupled to the connected equipment.

The 1.5-10V DC supply is fed in via CON2 and is filtered by a pi filter comprising the 10µF capacitor, a 100µH inductor and the 201nF of total supply bypass capacitance for IC1 and IC2.

IC2 operates as a switched capacitor charge pump which generates a negative rail for IC1, so that it can handle signals below ground. This can be an ICL7660, TC1044 or compatible device.

The ICL7660 operates at 10kHz while the TC1044 operates at up to 45kHz, so the latter should give less ripple on the negative supply. Both have a very high efficiency of around 98%.

They work as follows. Initially, the CAP+ terminal (pin 2) is connected to pin 8 (V+) while the CAP- terminal (pin 4) is connected to pin 3 (GND). Thus, the 100µF capacitor between pins 2 and 4 charges to the supply voltage; in this example, let's say 9V.

Then, internal switches (Mosfets) disconnect pins 2 and 4 and then pins 2 and 3 are connected (CAP+ to GND) and pins 4 and 5 are connected (CAP- to V_{OUT}).

With the top of the 100µF capacitor now at 0V, the bottom end is at -9V and this current flows through pin 5, charging the 100µF capacitor at that pin up to around -9V.

It won't be exactly -9V because the voltage of the switched capacitor will drop as it discharges into the second capacitor but since these connections are swapped 20,000 times per second, the capacitor doesn't have a lot of time to discharge (around 50µs) and since the load on the negative output is light, you can expect around -8.9V there.

There is a little bit of ripple in this output due to the switching action and this is filtered out using a second 100µH series inductor and 101nF worth of bypass/filter capacitors.

Clamp diodes D3 and D4 prevent the negative supply from going positive when the circuit is not powered and also protect IC1 in case the output is accidentally connected to a voltage source.

S3 should be closed for proper operation of IC2 if the supply voltage is below 3.5V. If the supply voltage is above 3.5V, leave it open.

Petre Petrov,
Sofia, Bulgaria. ($60)

OLED clock gets its time from the internet using NTP

I hate to adjust my clocks, so most the clocks in our house either get their time from GPS or they are showing the wrong time. Ever since I got an ESP32 microcontroller module with WiFi and Bluetooth, I decided to develop a clock that gets its time from the internet, using the standard Network Time Protocol (NTP).

This turned out to be really easy. I simply wired up a serial OLED display to the ESP32, wrote about 100 lines of code and the clock is up and running! In case my WiFi or internet connection drops out, the clock will continue running and will update its time at the next opportunity.

Precise NTP time is provided by atomic clocks distributed around the world. The servers are accessible using the Arduino NTPClient library (built into the ESP32). NTP automatically adjusts for the delay in receiving the time over the network connection, although it can't compensate 100% so it may be off by a few milliseconds. That's still pretty good!

The time received is in the PST (Pacific Standard Time) time zone. The code, therefore, needs to be changed to add your local time zone offset. Once that's done, it's simply a matter of updating the OLED.

There isn't much wiring to do. The OLED has an I²C controller so it's simply wired to the SDA (data) and SCL (clock) pins on the ESP32 module. The two power supply connections simply go to the 0V and 3.3V pins on the module.

5V power from a supply capable of at least 500mA can be fed in either via the V_{IN} and GND pins on the ESP32, or the micro USB socket. You could also run it from a regulated 3.3V power supply if required, fed into the 3V3 and GND pins. The current consumed is around 140mA.

The software is pretty simple. The setup() routine sets up the OLED display and establishes the WiFi connection. It has the option for providing two SSIDs and two WiFi passwords and the second set will be used as a fall-back if the unit cannot connect to the first network.

The main loop() function then updates the time, adds the local time zone offset, then updates the display with the time (hours, minutes and seconds), date and day of the week. It then repeats this as long as it has power.

Since the ESP32 is basically an updated version of the ESP8266 chip, the software could easily be adapted to work on an ESP8266 board; the following two lines are used to choose which board the software is compiled for. Simply move the two slashes from the start of the first line to the second line to compile for ESP8266:

```
// for ESP8266
//#include <ESP8266WiFi.h>
// for ESP32
#include <WiFi.h>
```

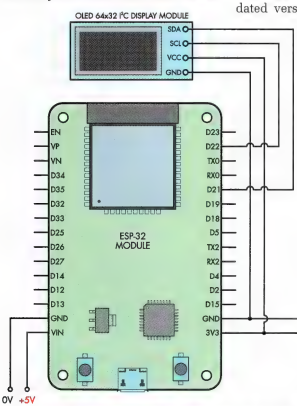
The total cost of the parts used for this project, purchased from eBay, came in under $20.

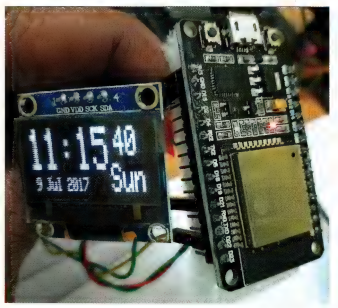
The Arduino sketch can be downloaded from the SILICON CHIP website and includes the required libraries as ZIPs. The libraries included are "NTPClient", "Time", "Adafruit_GFX" and "Adafruit_SSD1306".

You need to install these libraries, using the Sketch → Include Library → Add .ZIP Library menu option before the code can be compiled and uploaded to the ESP32 board.

You will also need to enable support for the ESP32 board in the Arduino IDE before you can compile it. It's a little involved but you just need to follow the instructions given here: https://github.com/espressif/arduino-esp32#installation-instructions

Bera Somnath,
Vindhyanagar, India. ($75)





A close-up of the finished clock. It uses an ESP32 to track the time which is then displayed onto an OLED screen. The default Network Time Protocol (NTP) is used to query the time, with a default server of time.nist.gov

SC ©2017 ESP-32 BASED WIFI NTP CLOCK

Arduino Mega Box Music Player

By Bao Smith

Combine an Arduino MP3 player shield with the Altronics Mega Box, along with our software, to make a neat little music or audio player with endless possibilities.

We introduced the Altronics Mega Box kit in the December 2017 issue of Silicon Chip. It allows you to give your Arduino projects a much more professional appearance and provides many convenient functions.

In that article, we mentioned that one possible use of the Mega Box would be to combine it with the VS1053 MP3 player shield, which we used in our Music Player project in July 2017 (see **siliconchip.com.au/Article/10722**).

That project was presented as a collection of boards and modules wired together. That's pretty typical for your average Arduino project but we wouldn't say that it gives a finished product that you can use every day.

Well, that changes now because we've revamped the software to take advantage of the facilities provided by the Mega Box.

By using the Mega Box, rather than just stacking the MP3 Player shield on an Arduino Uno, we can use a universal infrared remote control rather than the 4x4 keypad.

That provides several benefits including a larger number of keys and buttons, more intuitive user interface and the fact that you can carry the remote around with you.

We've also changed the software so that you can use at least two of the four illuminated pushbuttons on the front panel to control the player.

If you want to use the other two and the rotary encoder, you'll need to use an Arduino Mega instead of the Uno as the Uno just doesn't have enough free I/O pins. The software will auto-detect if you are using a Mega board and allow use of the extra front panel controls.

This version of the Music Player also incorporates the changes we've made to the software since the July 2017 article, to fix some issues reported by constructors. This includes a fix for dropouts during recording and an improved menu system.

Now, having mentioned how well the Mega Box suits this project, we should add some caveats. The Mega Box is supplied with a 16x2 LCD, which is smaller than the 4-line unit that we used in the original version of the project.

And since the supplied LCD has a slightly non-standard pinout, you can't easily attach an I^2C translator module (but it isn't impossible if you want to save four pins). So we need to use the LCD in 4-bit data transfer mode which requires the use of six of the Arduino's I/O pins (plus an additional PWM pin if you want to control the backlight).

Also, the way the MP3 player shield is designed means that the headphone and microphone sockets face into the box, rather than out through the hole provided near the rear of the shield mounting point.

That means you will need to drill a couple of holes to mount chassis sockets and wire them up to plugs which go into the shield sockets. Alternatively, you can run two 3.5mm male-female extension leads from the shield to the rear of the case.

As an alternative, you can use the SparkFun version of this shield (**www.sparkfun.com/products/12660**). It has the same pin layout but has the headphone jack pointed at the rear, but you will need to solder your own microphone input socket onto the board.

That shield is a bit more expensive than the version we used originally

Table 1: IR codes

Button	Hex code (0x)
Standby (on/off)	0C
Mute	0D
Buttons 0-9	00-09
Channel up/down	20/21
Volume up/down	10/11
Up/down	12/13
Right/left	14/15
OK	23
Teletext	3C
Page hold	29
TV/Video	3F
Pause	3D
Exit	0B
Rewind	37
Play	32
Fast forward	34
Stop	36

but it's also decidedly less dodgy, in that it uses a proper level translator between the 5V Arduino board and the 3.3V audio player IC.

The infrared interface is now the main means of controlling the unit and while you could probably use just about any universal remote, we've designed it with the Altronics A1012 in mind (**siliconchip.com.au/link/aaio**).

We're using TV code 170 (see supplied instructions for how to set that). You can use this to operate the unit from up to five metres away. The A1012 TV code 170 button codes are shown in Table 1.

If you want to use a different remote control, you will need to set it to produce Philips RC5 codes and then change the "#define" lines at the top of the Arduino code to the appropriate code numbers to suit your remote.

The best way to check what commands your remote sends are by running the sample Mega Box program that Altronics have on their website and read the values off the serial console in the Arduino IDE: **siliconchip.com.au/link/aais**

Assembly

Assembling the project is fairly simple if you've already built the Mega Box. If you haven't, see our December 2017 article for the details (**siliconchip.com.au/Article/10902**) and/or follow the instructions supplied with the kit.

The main difference will be in how you want to handle audio input and output. What we did was mount two 3.5mm stereo sockets in a convenient location on the front or rear panel (eg, above S1-S4, or to the left of the rotary encoder); a 6mm drill bit should do.

After this, solder an adequate length – depending on the location of the sockets – of stereo shielded cable to their pins. You can just use one cable and cut it in two and then strip the outer sheath.

Next, separate the individual leads and strip the ends of the red and white leads before soldering them to the connector; white to tip, red to ring and the shield wires to ground.

Be careful since some sockets are switched and will have more than three pins; you will need to plug an audio cable in and use a DMM set on continuity mode to figure out which is the tip (left), ring (right) and sleeve (ground) connections.

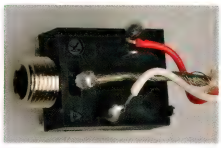
Wire these up to the two line plugs using the same pin assignments, so that you end up with what are essentially two extension leads that can then be plugged into the MP3 Player shield.

We also recommend that you add a 3.6V 1W zener diode between the 3.3V line (cathode) and ground (anode). The easiest place to fit this is between CON3 and CON5 which are located between the Arduino and the shield on the Mega Box board (these may be labelled U3 and U5 on the PCB).

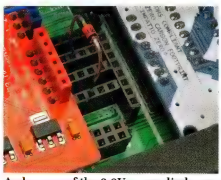
This is not necessary if you're using the SparkFun MP3 Player shield. The reason it's required is that the Geeetech MP3 Player shield's lack of level shifting circuitry causes the Arduino output pins to "pump up" the 3.3V supply when they go high and this can cause a buzzing in recorded audio.

The zener diode helps to prevent the loss of regulation on the 3.3V rail due to this pumping action. Note that there's a small risk that the diode could overheat; we're counting on the fact that its voltage "knee" is just above the normal voltage of the 3.3V rail and so it will only conduct a small amount of current (milliamps) at 3.3V.

But it's possible your diode could have a low knee voltage or your 3.3V



We've used a 3.5mm switched stereo audio socket (enlarged). You'll need to use a DMM on continuity mode to determine which lead is the tip (white; left), ring (red; right) and ground.



A close-up of the 3.6V zener diode inserted with cathode to the 3.3V line and anode to GND.

regulator could have a slightly higher output than typical. So after fitting it, power up the Arduino and make sure it isn't getting too hot.

Wiring it up

Now refer to Table 2 to see which connections you need to make using jumper leads. Some of the connections can only be used with an Arduino Mega, as indicated in the table, so if you're using the Uno you will have to leave them out and their related functions will not be available.

Since the pushbuttons are wired with pull-up resistors, the pins connected to the pushbuttons are read as high by default and low when pressed. The button's NO connection should be wired to +5V by placing jumpers on JP1.

Note that Arduino pins D2, D6, D7, D8 & D9 are exclusively being used by the MP3 Player shield and cannot be used for anything else, while D11-13 can be used with other SPI devices. This leaves D0 (receive), D1 (transmit), D3, D4 and D10 (slave select).

Generally, D0 and D1 should not be used as this would interfere with the serial console, nor D10 as that is driven by the Arduino SPI unit.

Once all connections have been made, the Arduino sketch software can be loaded. It's available for download from the SILICON CHIP website (free for subscribers, and it will be bundled with the July 2017 software).

You will also need to load your audio files **(and two required patch files)** onto the root directory of a properly formatted microSD card (FAT16 or FAT32) and insert this into the socket on the player module.

If you don't already have the latest version of the Arduino IDE, download it from **www.arduino.cc/en/Main/Software** and install it.

The next step is to install the required libraries, which are supplied in the download package along with the sketch. Use the Tools → Libraries → Add .ZIP Library menu option to install each one in turn.

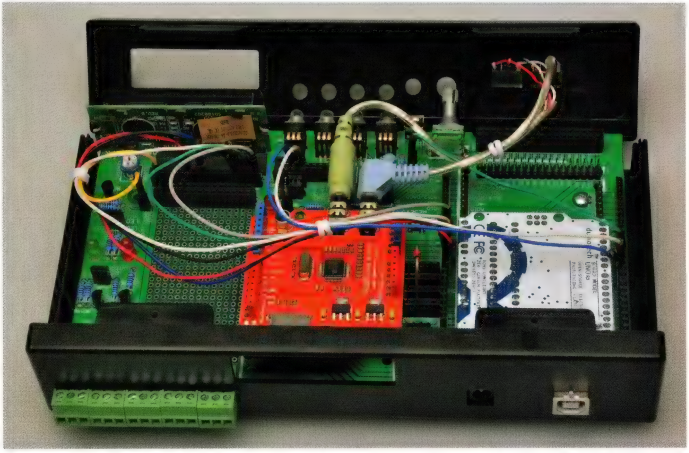
Then open up the sketch file, make sure the correct COM port is selected in the Tools menu, and then select the Upload option (CTRL+U in Windows). Check the bottom of the IDE window to make sure the upload was successful.

Next, adjust LCD contrast potentiometer VR1 so that you can comfortably read the text on the LCD screen. If you don't see any text, check that the SD card is properly connected and try connecting the LCD backlight interface to the +5V line to make sure the screen isn't too dim.

By default, the software uses the line in connection when recording, which means you will need an external microphone. You can alter the software to use the Geeetech on-board electret microphone by removing the line "#define USE_LINEIN 1", but the resulting quality is quite poor.

Remote control functions

You should find the infrared remote control buttons to be fairly straightforward. The arrow keys are used to navigate the menus with the OK button used to select the current choice.



Shown above are the flying lead connections that need to be made to use the project with an Arduino Uno. Take note of the jumpers for S1 & S2. If you have a spare PWM pin, the backlight can be controlled using that instead of the yellow lead going to 5V. The audio sockets don't need to be placed where we have as it does interfere with the header for the Arduino Mega. Other good locations include above the four pushbuttons or on the back panel above the five relays.

Table 2: Lead Connections

Component	Lead	To Pin
16x2 LCD	RS	A0
	EN	A1
	D4	A2
	D5	A3
	D6	A4
	D7	A5
	Backlight	5V
Infrared Remote	IR interface	D3
Pushbuttons	S1 COM#	D4
	S2 COM#	D5
	S3 COM^#	D14
	S3 COM^#	D15
Rotary Encoder	Encoder interface A^	D16
	Encoder interface B^	D17

Parts List

1 Inventa Mega Box kit (Altronics Cat K9670)
1 Arduino Mega (recommended) or Uno (or compatible)
1 VS1053b based MP3 Player shield (Silicon Chip Online Shop Cat SC4315 [Geeetech] or SparkFun version [see text])
1 Altronics A1012 universal remote control
4 jumper shunts (2 if using the Uno)
2 3.5mm stereo chassis-mount sockets
2 3.5mm stereo line plugs (Altronics Cat P0030)
1 1m length stereo shielded audio cable
1 USB Type A to Type B (full size) cable
1 USB charger or other USB power supply
16 150mm long male-male jumper leads (minimum 11)
1 3.6V 1W zener diode
1 Bluetooth audio transmitter (optional)
1 PCB-mount Type-A USB socket (for Bluetooth audio transmitter)

^ only available when using Arduino Mega board
 # place a jumper on JP1

Alternatively, you can press a button on the numeric keypad to directly choose the respective menu option (as shown on the LCD).

When playing an audio file, the up/down arrow keys and channel up/down will go to the previous or next file respectively. The OK, play and pause can be used to pause or play the current file.

Volume up/down will alter the volume, the mute button will toggle mute, fast-forward and fast-rewind will speed up or slow down playback, rewind will restart the current song from the beginning and the back/exit/return button on the remote will end playback.

When choosing the menu option "play track number", you use the numeric buttons on the remote to enter a specific three-digit track number to play. The left/right arrows can then be used to select which file format to play from (both MP3 and OGG are supported).

When recording, you will need to select a file number to record to and the process is the same. Or you can simply press OK to record in a sequential order, ergo, record00.ogg, 01, 02...

Using Bluetooth speakers

If you want to use Bluetooth speakers, headphones or some other Bluetooth audio receiving device, all you need to do is buy a Bluetooth audio transmitter.

They're quite cheap and compact. Here is one we've purchased and used quite successfully: **siliconchip.com.au/l/aair**

It can actually be used as a transmitter or receiver; dedicated transmitters cost around the same price (about $20). We found the audio quality to be reasonable.

It comes with a short 3.5mm plug-to-plug cable so it can be plugged straight into the audio output on the MP3 Player module. It's also supplied with a short USB cable to power it, with a Type-A plug on the end.

You will need to solder a PCB-mount Type-A socket to the prototyping area on the Mega Box and wire up its +5V and GND pins to supply points on the Mega Box board.

Fig.1 shows the connections required for the USB socket; the D- and D+ connections do not need to be made. Be careful since reverse polarity may destroy the Bluetooth transmitter.

You will then need to attach the transmitter inside the case somehow (eg, double-sided tape or silicone sealant) and then wire it to the socket with the supplied USB power cable.

If you're clever, you could drill a hole into the case giving you access to the button on the transmitter unit, which you need to press before you can pair it with your receiver.

However, given that pairing is something you only need to do when connecting it to a new receiver, that may not be necessary.

Fig.1: expanded view of a USB Type-A socket showing the required connections.

What can it play?

As mentioned in the previous article in July 2017, assuming you have the correct patch file located in the root directory of the SD card, the player can play these formats/containers: Ogg Vorbis, MP1, MP2, MP3, AAC, WMA, FLAC, WAV and MIDI

This should cover most of the audio file formats that you will commonly encounter.

The VS1053b chip is able to record in the following file formats: Ogg Vorbis, PCM and ADPCM.

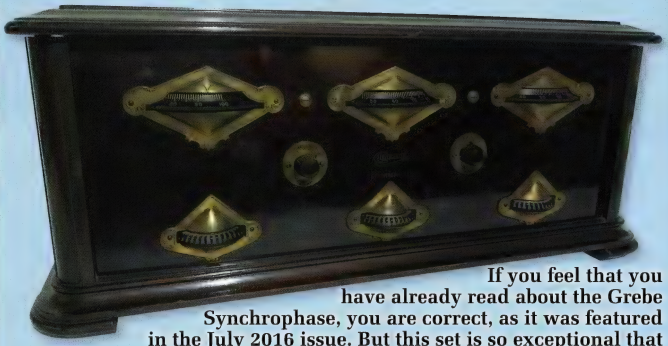
However, the software is only programmed to record in the Ogg Vorbis compressed format.

A list of individual bitrates which are supported by the IC for each file format can be found under section 8 in the VS1053 datasheet: **www.vlsi.fi/fileadmin/datasheets/vs1053.pdf** SC

Vintage Radio

By Ian Batty

A detailed look at the Grebe Synchrophase



If you feel that you have already read about the Grebe Synchrophase, you are correct, as it was featured in the July 2016 issue. But this set is so exceptional that it warrants a detailed analysis, explaining why its performance rivaled some of the finest superheterodyne sets of the period.

The first point to note is that it is not a superheterodyne circuit. Edwin Armstrong's famous patented circuit was well known at the time the Grebe was manufactured but the patent fees were expensive. So the Grebe Synchrophase is a Tuned Radio Frequency (TRF) set, using Hazeltine's Neutrodyne patent (www.google.com/patents/US1450080).

And while you have probably assumed that TRF sets are pretty basic stuff, with performance not much better than a crystal set and subject to unpleasant whistles and fluctuating volume from different stations, be prepared for some surprises.

While it may appear simple, the Grebe Synchrophase is a very well-engineered product that's one of the best examples of TRF design ever manufactured.

In the 1920s, radio pioneers must have been a persistent lot. The few stations that did exist were broadcasting at low power, and not always for 24 hours a day.

Still, the excitement of hearing the news before it arrived on your doorstep in the form of a newspaper, eavesdropping on the lives of movie stars, keeping up with the heroes and heroines of radio serials, hearing the latest weather reports and the most up-to-date doings of politicians... these were all just too good to miss out on.

But how to receive this avalanche of information? It was all well and good for Uncle Harry to teach Junior how to build a crystal set and tune into it instead of doing homework or playing in the yard but a family needed a family radio.

That meant a radio that would get more than just one station and play it over a loudspeaker, not the earphones of a crystal set that only one person could listen to.

And you could forget about putting up an aerial forty feet high and a hundred feet long like on Grandpa's

The label inside the cabinet gives detailed information about the battery connections, the function of the dial controls and dial settings as well as descriptions of the tone and volume controls. The chain drive links the three tuning capacitors, one for each stage, since tuning gangs had not been developed yet.

farm. City dwellers needed a good set that would work with just a few feet of wire.

Gain, gain and more gain

Edwin H. Armstrong, studying at Columbia University, had heard of the "howling" problem encountered by Lee de Forest and other experimenters working with early Audion (triode) amplifiers.

Reasoning that this was a form of uncontrolled regeneration, Armstrong turned a curse into a blessing. Controlled regeneration could give astounding improvements in receiver sensitivity but a regenerative set was tricky to tune and use. Bursting into oscillation, it would blank out all other receivers in the vicinity.

Do-it-yourself articles describing Tuned Radio Frequency sets abounded but you would be hampered by the natural anode-grid feedback capacitance of triode valves with their pitiful gains – tetrodes and pentodes were still some years in the future.

Further work by Armstrong produced the superheterodyne which remains a widely used technology to this day. US giants General Electric, RCA and AT&T bought Armstrong's superhet patents and those of another significant contributor, Reginald Fessenden.

The Independent Radio Manufacturers' Association (IRMA), frozen out of the superhet world, contacted Louis Hazeltine's laboratory for some other method of building high-performing radios. Employee Harold Wheeler produced the Neutrodyne, with Hazeltine filing U.S. patents 1,450,080 (7/8/1919) and 1,489,228 (28/12/1920) and throwing the IRMA a lifeline.

The Neutrodyne is simple. If a triode's anode-grid capacitance could be cancelled out, you could get its maximum gain. So you "just" need to apply a neutralising feedback equal to the (undesired) anode-grid signal, but in opposition to it.

This cancels out the undesired anode-grid coupling and also (equally important at radio frequencies) removes the effect of lowered input impedance caused by anode-grid feedback.

A feedback capacitance of "a few" picofarads might seem trivial but the amplifier's gain magnifies the Miller effect: a gain of only 8 applied to a $C_{g\text{-}a}$ of 5pF gives an effective value of 40pF. At radio frequencies, that's a lot in anyone's terms.

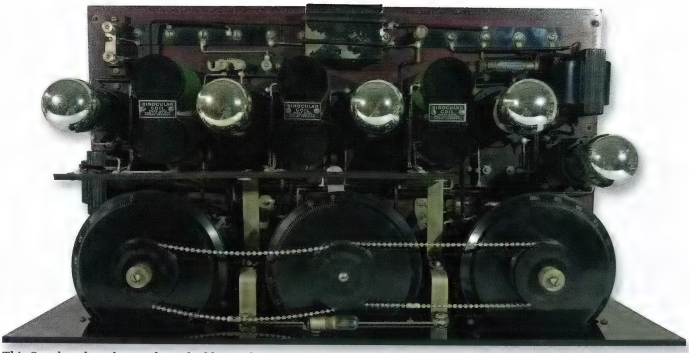
You can regard the Neutrodyne as a feedback circuit, but it's more useful to regard it as a balancing circuit. Now the concept of electrical balance had been understood for some 80 years in circuits such as the Wheatstone Bridge, first popularised in 1843.

Indeed, the Hazeltine patents describe their principles solely in terms of neutralising. And as noted below, our modern concept of feedback had not even been described at the time, let alone fully understood.

A neutralised triode circuit becomes a simple amplifier and the problems of feedback and oscillation are removed. We can go back to a straight TRF radio, where every RF stage works at the signal frequency, without Armstrong's novel and (in the early days) the troublesome complexity of the superhet. Even partly tech-savvy customers could grasp the Neutrodyne concept.

Enter George Grebe, born in 1895. Having built and supplied "submarine receivers" for the U.S. Navy during WWI, he viewed the burgeoning domestic radio market with anticipation. People wanted radios, radios and radios, of any kind.

Beginning with regenerative sets, Grebe moved on to the prestige end of the market. The Synchrophase was (and still is) widely recognised



This Synchrophase has trademarked binocular coil plates which became a feature of sets produced after mid 1925. Another production change was the small lamp (actually made by Mazda) below the centre dial which was powered by the filament line and would light up when the radio was turned on.

as the best non-superheterodyne set of its day.

Grebe's problem was that he was not a foundation member of the IRMA, so he was in breach of their ownership of the Hazeltine patents. A lawsuit reached court in 1927 but by then Grebe had sold some 150,000 sets and the growing acceptance of Superheterodynes meant that the Synchrophase (like all Neutrodynes) was reaching the end of its commercial life anyway.

Design highlights

The Synchrophase was aimed squarely at the prestige market. Its luxurious mahogany cabinet, with dark Bakelite front panel and gold-plated trim, combines with Grebe's patented chain drive tuning to offer one-touch operation. Given the flip top and compact width, I guess this is a "mini-coffin" set.

It might have been all sizzle and no sausage but Grebe sensibly realised that a high-priced radio needed to offer superior performance. That implied two things: sensitivity and selectivity. Sensitivity was a major problem with TRFs, since they needed to optimise gain but somehow reduce undesired coupling between stages.

Binocular coil design

P. D. Lowell, working for Grebe, designed the unusual "binocular" interstage coupling coils. As pointed out by Dr Hugo Holden in the July 2016 article on the Grebe, the two coils in each "binocular" are connected in series and are placed beside each other.

Because the windings run in opposite directions, this reduces their mutual coupling. Any signals (eg, from radio stations or due to interference) picked by this coil arrangement induces out-of phase signals in the two coil halves and so they cancel. There's also reduced unwanted signal pick-up from radio stations because of the parallel orientation of the coils.

The result was similar to that achieved with coil shielding but with no actual metal shield which always has the effect of lowering the circuit's Q. This physical design greatly reduced magnetic coupling effects between grid and anode circuits, allowing the coils to be assembled vertically onto the baseboard.

This was an elegant arrangement and an ingenious solution to preventing coupling between interstage coils. In fact, it seems similar to the thinking behind the design of today's common mode filter chokes which have two

This photo shows the construction of the binocular coils which each comprise a pair of formers wound in opposite directions with green Litz wire. In front of the closest coil there is a small lamp that acts as a series fuse for the 90V B+ rail.

windings on a common toroid core. Is this yet another case of "nothing new under the sun"?

This coil arrangement was devised in the early 1920s and the designer must have had a clever insight in to the problem.

Other designers, lacking this technique (and insight), were forced to reduce coupling by offsetting coils at different angles to each other. While such offsetting works, it just looks awkward and amateurish.

The Synchrophase's physical presentation is just what you'd expect from a set costing some 155 USD in 1924 or around $2750 in today's Australian currency.

So the Synchrophase exhibited good sensitivity, but what about selectivity?

Selectivity allows a radio to respond to a desired station while rejecting those nearby. Superhets, with their fixed-frequency IF amplifiers, can be designed for high selectivity that's constant across the tuning band.

Selectivity (Q) is controlled by (i) resistive losses (principally due to inductors) and (ii) the LC ratio. TRFs suffer from variations in Q as the LC ratio changes with tuning.

A high Q gives good selectivity but tuned circuit Q is mostly compromised by the RF resistance of inductors. It's mostly due to skin effect, where RF current flow is largely confined to the conductor's surface. The solution to this problem is to use multi-stranded Litz wire.

The bother of stripping and tinning every one of a bundle of 20 wires is well compensated for by their combined surface area: Lowell's 20/38 Litz has the surface area of single-strand of 28 AWG but the bundle is more flexible. In practice, Grebe engineers did laboriously tin each individual wire, then tested the actual RF resistance once assembled.

Let's talk about feedback

An article in April 1925 QST, by Grebe engineer R. R. Batcher, asserts that it was component quality rather than use of the Neutrodyne principle that gave Grebe sets their performance edge. Well, yes and no.

It's true that the Synchrophase is superbly engineered by any standard. But the cancellation of feedback probably plays a larger role than Batcher (or anyone) probably realised back in 1925. Bell Labs' famous Harry Black did not lodge his patent for negative feedback (with its engineering description) until late 1928.

Feedback from output to input (whether positive or negative) modifies gain: that's why it's so widely used in analog circuitry. Negative feedback is overwhelmingly used, and it reduces gain.

But also, the anode-grid feedback in triodes (shunt voltage feedback) reduces input impedance. Indeed, this design is used with solid-state op amps to create a virtual ground node of (theoretically) zero impedance.

So un-neutralised triode amplifiers present a low impedance to their inputs at Broadcast frequencies, rather than the almost open-circuit that a valve should exhibit. Anode-grid feedback would create significant loading of the grid tuned circuit, thus reducing gain and compromising selectivity.

Selectivity is specifically addressed in Hazeltine's 1924 patent US1489228, and input circuit loading is specifically addressed (as "increased input conductance") in that patent (note that increased conductance means reduced resistance/impedance).

The third potential problem of oscillation could be (and was by some other manufacturers) overcome by circuit damping. But this also reduces both gain and selectivity – the two highly desirable characteristics that Grebe engineers were able to optimise and which set the Synchrophase apart.

So the Neutrodyne principle's balancing-out of anode-grid capacitance (ie, isolation of an amplifier's grid circuit from its anode circuit) was vital to the Synchrophase's performance, allowing its refined tuned circuits to operate at their peak of selectivity, and the amplifiers at their peak of sensitivity.

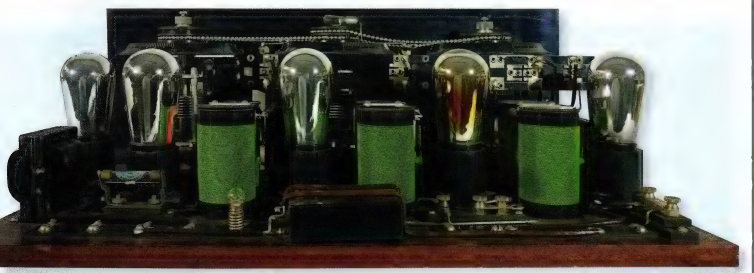
A final note: is the Neutrodyne a positive feedback circuit? Yes, you can describe it that way. Remember that the purpose was to achieve the theoretical maximum gain from a stage, not to increase it over that maximum (the purpose of regeneration).

Is it possible to increase the positive feedback beyond the point of balancing and get extra gain? Yes. I was able to push the Synchrophase into regeneration and ultimate violent oscillation by maladjustment. Is this cheating, against the purpose of the Neutrodyne principle and just plain wrong? Yes, yes, and yes.

But it is a TRF, after all.

So how does a sensitivity of 8 microvolts for 10 milliwatts output sound? And in the HF band?

The BC-AN-429 military aircraft receiver (kitted out with pentode RF am-



plifiers) managed this over its lowest HF range of 2.5-7MHz, rivalling that of its more famous superhet "Command" successors. Could the Synchrophase get anywhere near that benchmark?

Circuit description

The Synchrophase, like other Neutrodyne designs, is simplicity itself, as can be seen in the circuit diagram overleaf. Like other sets of the era, its component count is "economical". LT (filament) power was commonly from a 6V lead-acid battery, regulated via one or more filament rheostats.

"Gasoline Alley", a comic of the day, shows the man of the house driving around and around the block: he's taken the radio battery for an outing to charge it!

HT batteries came in some multiple of 22.5V and were connected in series, the highest voltage for the output stage, lower voltages for the demodulator and RF stages. Bias was very often supplied via a tapped battery, with outputs at 1.5 or 3V.

Given the ready availability of battery-supplied voltages and the natural low impedance of such batteries, the Synchrophase has just two bypass capacitors, C3 and C12, both 1µF.

The set covers frequencies 545-1900kHz in two bands: 545-1250kHz and 1200-1900kHz. Turning the dial to either extremity of its range trips a lever that operates a 3-pole slider switch.

The switch cuts in (or out) part of each of the binocular coils and it's also possible to do this manually (as can be seen at the bottom of this page).

The aerial circuit, in common with many early sets, provides for "long" and "short" wire aerials or for a tuned loop aerial. If using a loop, it's important that it is of the correct inductance for proper tuning.

All valves in this set are UX201As, similar to the iconic '01, but with reduced filament current of only 0.25A.

Later sets used a UX112 in the final stage for greater audio output. V1 and V2 operate as common-cathode, tuned RF amplifiers.

The proprietary "binocular" coils are secondary-tuned by C2 and C4. Neutralisation is provided by C3 and C5. The bias battery supplies a common bias voltage of -4.5V while the HT supply is +90V.

Demodulator V3 operates with grid leak bias, returned to its filament, rather than to the -4.5V ground potential. C7, although similar to C3 and C5, does not neutralise; it's there to match the circuit capacitances of C3 and C5 so that V3's tuned grid circuit tracks those of V1 and V2.

The tuning capacitors use plates cut to give a straight line (linear) frequency calibration, preventing crowding of stations at the top ends of the bands. This is shown in the diagram directly below.

V3 feeds 1st audio V4 via driver transformer T1. This has a step-up ratio of around 4:1. The demodulator runs from a +45V supply.

All three RF stages are tuned together via Grebe's patented chain drive system that mechanically couples the three separate tuning capacitors. Note that the now commonly-used multi-gang capacitor did not appear until F. W. Dunmore's competing patent on the 23rd of March 1926.

First audio amplifier V4 uses another step-up transformer to drive output valve V5. Together, T1 and T2 give more gain than an extra UX201 without the cost of an actual valve and its power consumption.

Be aware that such transformers can have very high resistance windings. We're probably accustomed to conventional valve output transformers with primary resistances around 500Ω.

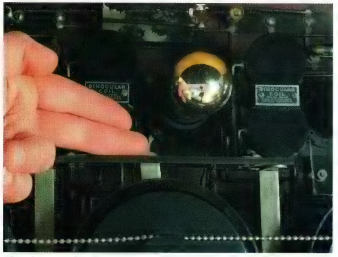
Because these are loaded (by loudspeakers), the natural combination of inductance and winding capacitance is well-damped and any peak exhibited by the winding is commonly damped by small shunt capacitor.

Interstage transformers, fed by a triode of some 10kΩ source impedance, matching into the following grid of near-infinite impedance, do exhibit significant resonance within the audio band.

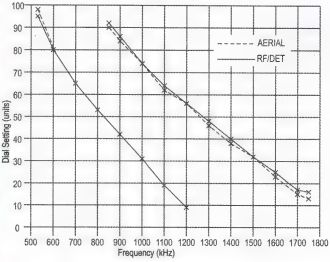
The solution was to use high-resistance wire for primary or secondary (or both) to damp out the resonant peak.

T1 and T2 both have primary resistances of 300Ω and secondaries of 6.6kΩ. So if you're working on one of these set, don't be misled into assuming an interstage transformer with high resistance has a faulty winding.

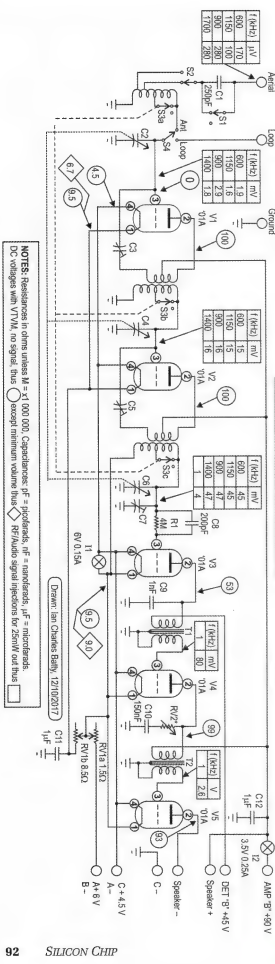
As this set uses a UX201A for output amplification, it shares the common -4.5V C supply and the common +90V HT. Sets using the UX112 need an extra bias voltage of -9V and use an HT supply of +135V.



The three-pole slider switch shown the the centre of this photograph can be used to manually change the operating band.



This diagram shows the straight-line tuning characteristic of the Synchrophase.


Aerial
Loop
Ground
Amp
Loop
Ant
Ground
S1
S2
S3
S4
S5a
S5b
S5c
S6
S7
S8a
S8b
S8c
C1 250pF
C2
C3
C4
C5
C6
C7 200pF
C8 1nF
C9 1nF
C10 150pF
C11 1µF
C12 1µF
RV1a 1kΩ
RV1b 8.5Ω
RV2
V1 01A
V2 01A
V3 01A
V4 01A
V5 01A
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
[kHz] µV
600 170
1000 280
1300 280
1700 280
[kHz] mV
600 1.9
1000 2.3
1400 1.8
[kHz] mV
600 15
1000 15
1300 16
1400 16
[kHz] mV
1 1
200 45
300 47
400 47
1400 47
[kHz] mV
1 80
[kHz] V
1 2.6
6V 0.19A
3.5V 0.25A
Aerial
Loop
Ground
A+ 6 V
A– 0 V
C+ 4.5 V
C– 0 V
Speaker –
Speaker +
DET 'B' +4.5 V
ANT 'B' +9 V
Trevor Marshall
Trevor Marshall
Trevor Marshall

Using the standard dummy antenna, I needed 170µV at 600kHz, 100µV at 1150kHz and 280µV at 900kHz and 1700kHz. Signal-to-noise ratios well exceeded 20dB for all settings.

Audio bandwidth was surprising: I found -3dB bandwidths of ±1.2kHz at 600kHz, ±3.5kHz at 1150kHz, ±1.2kHz at 900kHz and ±8.5kHz at 1700kHz.

Frequency response from antenna to speaker terminals was around 350Hz to 2.5kHz for -3dB the points at the 1700kHz end, indicating that the audio transformers have limited low and high frequency performances.

If the figures sound pretty good, consider the detailed stage injections on the circuit. You'll see that, for my 100µV input at 1150kHz, I needed around 1.6mV at the 1st RF grid. This implies a circuit gain of some 16 times in the antenna coupling and its tuned circuit. It's a reminder of just how well good circuit design can contribute to a set's performance.

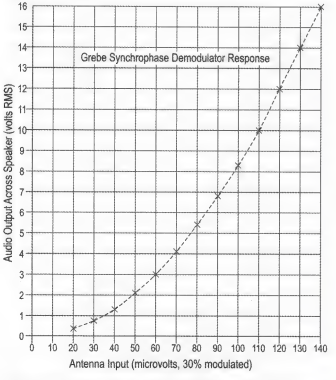
The difference in sensitivities between the two bands is probably due to the band-change mechanism, which appears to short out the unused sections of the RF coils. I had wondered about a "shorted turns" effect and figures seem to bear it out.

Volume control was pretty effective: turning down all the way demanded some 35mV at 1700kHz, implying a gain reduction of around 42dB.

How good is it?

It's great. Grebe gave us a set with sizzle and sausage, and it hits both of my criteria for collecting: it's a visual treat that people find attractive and charming, and it's technically refined and a great performer.

Would I buy another? One is enough but you can still find them for sale at affordable prices. Given its great visual design, if you want a "real" radio, and one that's compact enough to fit most shelves, it's hard to pass by.



This diagram shows the audio output versus the antenna input. Note that it is not a straight line and this is the reason for the relatively high harmonic distortion in the Grebe MU-1.

Synchrophase versions

"A new set every week!" while it was not really a Grebe slogan, there were many versions. Model coding is mysterious and confusing but the "radioblvd" reference located under "Further Reading" has useful information.

Special handling

In some sets, the 01 and 01A use a locking pin to secure the valve in the socket; the pin tips make contact against flat "leaves" at the bottom of the socket rather than sliding into socket contact sleeves used in later equipments.

The pin indexes the valve, so insertion requires matching the pin, pushing down and gently twisting clockwise a few degrees. Removal is the opposite but excessive twisting can detach the envelope from the valve's Bakelite base. Use care.

Further Reading

The 1924 review appears at: www.greberadio.com/?page_id=101

Batcher's QST review of 1925 (four scans) appears at: www.atwaterkent.info/grebe/Articles/QST2504.html

There's an excellent Synchrophase site at: www.radioblvd.com/Grebe%20Synchrophase.htm

Set manufacture: www.youtube.com/watch?v=2ovD5lX53Ck

And don't forget Ernst Erb's comprehensive site. It has the MU2 and many other Grebe sets at: www.radiomuseum.org/r/grebe_synchrophase_mu2_1.html SC

Thoriated-tungsten filaments

The first generation of valves used either tungsten or tantalum filaments, a natural consequence of their light bulb predecessors' technology.

These were also the only available metals that could give useful emission and stand the extremely high temperatures needed, around 2200°C. This was close to tantalum's melting point, so tungsten became the material of choice

It was known that thorium, for instance, would give improved emission at lower temperatures, but that it was incapable of being formed and used at the 1700°C required for useful emission.

The solution was to coat a tungsten filament with a very thin thorium coating, and to run the tungsten at the 1700°C needed. Where tungsten gave only about 5mA of emission per watt of heating power, thoriated-tungsten improved this to 100mA/watt.

Thoriated tungsten also offered much longer life than pure tungsten "bright emitters", but was still capable of the very high emission currents demanded in transmitting valves.

Further development led to oxide-coated cathodes used in receiving valves and low-power transmitting valves. These commonly use a combination of barium, calcium and strontium oxides, giving emission currents of 500mA/W and operating temperatures around 700°C.

Oxide-coated filaments are used in battery-powered octal, miniature and subminiature valves.

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Mounting the 6GHz+ Frequency Counter

I'm very interested in building the new Touchscreen Frequency Counter in November 2017 edition of SILICON CHIP (siliconchip.com.au/Series/319) but I am not too keen on the case idea. Being a bit more traditional perhaps, I prefer the standard metal case type way of housing. Plus a built in power supply.

It seems that if I fit right-angle header pins to the Micromite Explore 100 board then the display could mount onto a front panel, with the coax sockets at the bottom and projected out the front of the case.

This would mean however that the display would be upside-down compared to your design. To that end, would you consider adding a switch in the firmware such that the presumed spare pin, AN11/RB11, could be used to select this inverted display mode? (G. P., via email)

● The display orientation is easy to change as this is configured using an MMBasic command. See the part two article in the November issue for the instructions. This is done over the serial console as part of the set-up procedure. Just use a different orientation than specified. The Micromite Plus manual PDF has the details of how to specify the display orientation.

You may be better off using a short ribbon cable to connect the two boards as that would give you more flexibility in mounting.

Larger screen for 6GHz+ Frequency Counter

Congratulations on producing a great magazine. I look forward to my copy every month.

Some time ago, I built the Micromite Plus Explore 100, more as an exercise in my SMD skills than a need to program and use it. So it sits here doing not much. I note that in the October issue, you have a new Frequency Counter (siliconchip.com.au/Series/319) project using the Micromite Plus Explore 100 module.

I built mine with the larger 7-inch diagonal display. The Counter project would be ideal to let me use the Micromite to actually do something useful. Will the larger display work in this Counter project? I'll simply house it in a larger enclosure. (G. M., Torquay, Qld)

● On page 71 of the Micromite Plus article in the August 2016 issue, it states that the 5-inch, 7-inch and 8-inch LCD touchscreens supported by the Micromite Plus all have the same resolution. That being the case, we can't see any reason why the software won't work with the larger displays. However, we don't have any of these larger displays and have not tested it.

Arduino Data Logger with Depth Sounder

Please forgive my ignorance. Can the Arduino Data Logger (August-September 2017; siliconchip.com.au/Series/316) be used to record the NMEA output from a sounder unit? I currently feed the combined depth/position NMEA output from my Humminbird sounder into a Brookhouse data logger.

Post-survey, I download the logger using Tera Term and then further process using Surfer to get the depth contour map.

This project is interesting in more ways than one. (F. B., Penrith, NSW)

● It should work in theory but some minor adjustments to the software may be required.

Firstly, you would need to add some code to extract the depth information from the NMEA stream and write it to the log file as the GPS library we've used only extracts information such as the date, time, position and number of satellites. See the September article for details on how to log additional data.

Secondly, the Data Logger sketch expects a TTL serial stream at 9600 baud. The Depth Sounder may use 4800 baud and it may use RS-232 signalling which is inverted compared to TTL. The GPS baud rate is set by this line and so is easily changed:

```
nss.begin(9600);
```

Assuming the signal is not already TTL, the simplest solution may be to use a converter like this: siliconchip.com.au/l/aaiq

However, it would be possible to do the inversion in software by changing the AltSoftwareSerialReceiveOnly library code. In that case, the only hardware change required would be a series resistor of around 4.7kΩ between the serial output of the Depth Sounder and the serial input pin on the Arduino shield.

We haven't tried modifying this library to invert the signal. It would involve changing all the calls to CONFIG_CAPTURE_FALLING_EDGE() to be to CONFIG_CAPTURE_RISING_EDGE() and vice versa. It would also be necessary to change the line which reads:

```
capture = GET_INPUT_CAPTURE();
```

to:

```
capture = !GET_INPUT_CAPTURE();
```

That should be all that's necessary to get the unit to handle an inverted serial stream but note that we haven't tried this.

Queries about the Super Clock

My father found the July 2017 issue of *Every Day Practical Electronics* (EPE) here in the States, containing the construction of the Super Clock (originally published in SILICON CHIP, July 2016, siliconchip.com.au/Article/10004).

Let's just say that with him being an amateur horologist, he was impressed enough to ask me to look over the article, schematics and DS3231 RTC module.

From everything I've read, it seems like an amazing circuit for basic timekeeping of a clock.

I have actually been looking for something to keep time on my own clock project and this will be my test run for this one. I do have three

questions about your Super Clock kit:

1. Is the DS3231 included with the kit? I did not see it specifically called out as an item or add-on, as I did the GPS module.
2. The UB3 box appears to be an Australian standard project box as I could not find it from my suppliers here in the USA. Do you have a preferred vendor to purchase them?
3. The UB3 lid that is listed and laser cut: is this cut for both the display screen and mounting screws?

As it stands even with a response I will be purchasing two of these for each of us. (J. W., via email)

● You do not need the RTC module if you are using the GPS module. The time-keeping will be much more accurate with GPS than with an RTC which will gain or lose about one second a month.

Our kit for the Micromite LCD BackPack includes a 2.8-inch touch-screen LCD panel, the BackPack PCB, a PIC32 microcontroller programmed with Super-ClockFull.hex, all the on-board parts and a laser-cut black or clear acrylic lid with a cut-out to suit the LCD and mounting holes to suit a UB3 box (the black lid has a gloss finish on one side and a matt finish on the other).

Note that the kit does not include the DS3231 or GPS module, the box, mounting hardware, power supply, DC socket, off-board headers or any connectors or cable parts.

The UB3 box is available in the USA from the Jaycar international website: www.jaycar.com (Cat HB6013).

The BackPack PCB and a programmed microcontroller are also available separately.

We also have available the DS3231 RTC module (back-up battery not included) plus two M2 x 10mm Nylon spacers and four M2 x 6mm Nylon screws for mounting. In addition, two different GPS modules with internal battery back-up are available and these are each supplied with a connecting cable.

Finally, suitable USB-to-serial converters are on offer and these are each supplied with a short DuPont cable to connect to the Micromite.

Remote control settings for unidentified preamp

I have acquired an already built kit preamp. The only thing written on the case is "SILICON CHIP STUDIO REMOTE PREAMPLIFIER". It came with no remote and also no source/input selector switch/button on the unit.

I need to change it to phono to use it as a turntable preamp. I have a universal remote. Are you able to tell me the best code/manufacturer setting might get it to control the unit? (Guy, via email)

● This sounds like a home-built version of our Studio Series Preamplifier (ie, not built using the Altronics kit, K5500).

The design was published in the October and November 2005 issues (siliconchip.com.au/Series/320), with the remote control module described in the April 2006 issue.

The Studio Series Preamplifier does not contain a phono preamplifier or any RIAA equalisation circuitry. If you want to hook it up to a record player, you will need to build a separate preamp such as our Magnetic Cartridge Preamplifier design from the August 2006 issue. See siliconchip.com.au/Article/2740

This unit can be built to suit playback of 78 RPM records, as well as standard 33 & 45 RPM microgroove vinyl records. It is available as a short-form kit (without diecast case) from both Altronics (siliconchip.com.au/link/aaij) and Jaycar (siliconchip.com.au/link/aaik).

With regard to your query about suitable universal remotes, you will need to refer to the relevant article from the April 2006 issue. See siliconchip.com.au/Article/2625

It explains that the Preamplifier is set up to expect codes for a Philips TV, CD or Satellite receiver. So check the manual for your universal remote and try a few different codes until you find one that works.

Watering controller wanted

I have been going through my store room and came across a Game Boy. I remember that there was an article to use a Game Boy for a watering controller for the garden. Can you help find which magazine it was in? I have the magazines back to 2002 but it might have been before this. (B. M., Kiama Downs, NSW)

● We have published several watering systems based on PICAXE microcontrollers but we can't find any based on a Game Boy.

Winding the coils for the Planet Jupiter

I hope that not too many years have passed to ask for advice on your Planet Jupiter Receiver project (siliconchip.com.au/Article/1902) from SILICON CHIP which I came across in the British *Everyday Practical Electronics* magazine.

I have sourced all the components but as you know, the Jaycar coil formers

Using Burp Charger with lithium cells

Recently, lithium rechargeable cells have appeared on the market. I would appreciate it if you could update your Burp Charger information to give some help as to charging rates etc.

I have found that your charger performs very well on the NiMH batteries and at this time, I am in the process of putting some of the controls on the lid, to facilitate changing from AAA to AA cells. (J. H., Motueka, NZ)

● The Burp Charger is not suitable for use with lithium cells or batteries.

Here are two charger circuits published since the Burp Charger which are suitable for use with lithium cells and batteries:

August 2016: Circuit Notebook: Simple Li-Ion Cell Charger by Phillip Webb (siliconchip.com.au/Article/10045)

April 2014: Circuit Notebook: 2-cell lithium-polymer charger has balancing feature by Robert Budniak (siliconchip.com.au/Article/7171)

And here are two cell balancer/equaliser circuits, which need to be used with a separate charger that suits lithium chemistry:

March 2016: Battery-Pack Cell Balancer For Optimum Charging by Nicholas Vinen (siliconchip.com.au/Article/9852)

April 2015: Circuit Notebook: Lithium battery cell equaliser by David Francis (siliconchip.com.au/Article/8443)

are discontinued and alternatives are not obvious. I intend to turn my own formers from plastic stock but I can't see how I can wind L2, 1.8µH with 20 turns on a 3mm (as in the text) core given the coil height would be about 5mm.

It comes out around 0.6µH. Am I correct to use an air coil calculator for this? A 6mm diameter coil would be about right.

I'm probably missing something obvious here as radio is not my usual frequency range! (S. M., via email)

● We can supply an RF Coil Former Pack (SBK-71K) from our online shop. There are some differences to the Jaycar LF1227 set, so some slight modifications need to be made in order to fit the new coil formers onto the PCB:

1) The SBK-71K has five pins rather than two. The extra pins can be cut off or where they will fit into an existing PCB mounting hole, used as tap connection points.
2) The SBK-71K is slightly smaller so you will need to use 0.25mm diameter enamelled copper wire rather than the 0.3mm diameter specified in the parts list.
3) You may need to bend the pins slightly to fit them into the PCB mounting pads.

We should also note that both the L1 and L2 tuned circuits are of fairly low Q, so they cover virtually all of the required tuning range.

So a small discrepancy in inductance can be compensated by the settings of trimmers VC1 and VC2. Alternatively, you could also wind an extra 3 or 4 turns on each (there should be room for the extra turns of 0.25mm enamelled copper wire).

The situation regarding oscillator coil L3 might seem a little more critical, but on the other hand this one is tuned over the desired range using VC3, with its much larger capacitance range (10-120pF). If needed, you'd get around the problem by winding 3 or 4 extra turns on L3 as well.

Best way to check for irregular heartbeat

I am writing regarding the February 2005 USB-Controlled Electrocardiograph article (siliconchip.com.au/Article/2972).

I looked at building this, in response to feeling (and hearing) the odd irregular heartbeat, as probably do many older persons. Techniques and components have obviously changed enormously, making old circuits questionable. Using electrodes will obviously require a good op amp.

Could a stethoscope be a reasonable alternative? The peaks would not be sharp, but almost certainly adequate for diagnosing irregular heartbeats.

Presumably a modern microprocessor and probably the Micromite will be fast enough to put a digitised record of sound pulse shapes appearing at 60 to 120 peaks per minute into a memory record.

That could then be played back onto either the microprocessor's own screen (Micromite set up), or on a notebook. The notebook version could then also be printed like an ECG. Obviously not as good as an electrocardiograph but for an older person an easy record to take to the doctor. Could also be played back as sound, as though the doctor were using his stethoscope at the time of recording.

The hardware set up would be simple and cheap. (C. B., Manypeaks, WA)

● If you think you have an irregular heartbeat, you should see your GP right away!

Getting back to your question, that project has been superseded by an Arduino-based version in the October

Radio, Television & Hobbies: the COMPLETE archive on DVD

This remarkable collection of PDFs ***covers every issue*** of R & H, as it was known from the beginning (April 1939 – price sixpence!) right through to the final edition of R, TV & H in March 1965, before it disappeared forever with the change of name to EA.

For the first time ever, complete and in one handy DVD, every article and every issue is covered.

If you're an old timer (or even young timer!) into vintage radio, it doesn't get much more vintage than this. If you're a student of history, this archive gives an extraordinary insight into the amazing breakthroughs made in radio and electronics technology following the war years.

And speaking of the war years, R & H had some of the best propaganda imaginable! Even if you're just an electronics dabbler, there's something here to interest you.

- **Every issue individually archived, by month and year**
- **Complete with index for each year**
- **A must-have for everyone interested in electronics**

ONLY $62.00 +$10.00 P&P

Exclusive to: SILICON CHIP

Order now from www.siliconchip.com.au/Shop/3 or call (02) 9939 3295 and quote your credit card number.

2015 issue. Have a look at siliconchip.com.au/Article/9135

A kit for that project is available from Altronics; see siliconchip.com.au/Shop/Altronics/K2523 It works well; we don't see the point of producing a sound-based version which would likely give inferior results.

Replacement ignition system for 200cc scooter

I have a single-cylinder, single-coil 200cc motorbike with a failing electronic ignition. It has a transistor-controlled ignition (TCI) unit which receives its signal from a pickup coil (of approximately 114Ω).

Would your High Energy Ignition for Cars from the November and December 2012 issues (siliconchip.com.au/Series/18; Jaycar kit Cat KC5513) work on my scooter and does it have a option to adjust the timing curve? (B. P., New Zealand)

● It may be that your ignition is actually a capacitor discharge ignition (CDI) where a high voltage coil generates around 300V DC to charge a capacitor and the trigger coil fires the CDI to produce a spark from the ignition coil high tension lead. We have published a replacement CDI unit for this type of ignition.

It was in the May 2008 issue and titled "Replacement CDI Module For Small Petrol Motors" with an Altronics kit (Cat K4025) and Jaycar kit (Cat KC5466) available. See: siliconchip.com.au/Article/1820 This design has the ability to have different spark advance depending on the trigger coil design.

If you are after the High Energy Ignition, a 12V battery is required. You could use the reluctor input circuit to suit the pickup coil.

We published High Energy Ignition projects in the November-December 2012 issues (siliconchip.com.au/Series/18; Altronics kit Cat K4030) and a Programmable Ignition system in the March-June 2007 issues (siliconchip.com.au/Series/56).

USB-controlled power board wanted

I was reading your article on the USB-controlled Power Switch (power board) from the November 2004 issue (siliconchip.com.au/Article/3679) and I see that the Jaycar Kit, Cat KC5401, is no longer available.

Do you know anyone who makes an equivalent device? I'm looking to build up an arcade and would like my Raspberry Pi to turn on the power to the rest of the devices. (T. F., via email)

● Jaycar used to sell a pre-built USB-controlled power board but that too has been discontinued (Cat MS-4032). We also found this one on the internet but it doesn't seem to be available any more: siliconchip.com.au/link/aail

We're not sure why this sort of device has suddenly become difficult to purchase. The simplest solution would be to buy a remote-controlled power board like the Jaycar MS-6154, disassemble the remote and drive its buttons using transistors controlled by the Raspberry Pi outputs.

We did something similar with our "Programmable Mains Timer With Remote Switching" project in the November 2014 issue. See siliconchip.com.au/Article/8063

Active crossover with Majestic loudspeaker

I have already built your Majestic loudspeaker and it is awesome. Can I change it to an active speaker, using the SILICON CHIP Active Crossover? Or is that not workable because the Majestic has a full enclosure? (J. S., via email)

● Theoretically, a good active crossover system such as the one described this year (September & October 2017; siliconchip.com.au/Series/318) would offer lower distortion, better phasing and better control of cut-off frequencies and amplitudes than the passive 6dB/octave crossover we used in the Majestic design in the June &

Locating Anti-Fouling transducers on 12m fibreglass boat

I previously built a two-channel version of the Ultrasonic Anti-Fouling project as described in SILICON CHIP, May and June 2017 (siliconchip.com.au/Series/312).

I had a small issue with getting the unit to start reliably but thanks to John Clarke's assistance, was able to overcome that and the unit is installed in the boat and has been happily running for a couple of months now.

Unfortunately, I have not been able to get the boat lifted and cleaned/anti-fouled since fitting the unit so I am not able to make any comments on the effectiveness as yet.

My boat is just under 12m and of fibreglass construction. Ideally, I should have fitted one transducer towards the stern and one towards the bow.

As it is extremely difficult to get a cable from stern to bow, I actually fitted both transducers to the stern, one on either side.

I am well aware that having a transducer towards the bow would be more effective and there is a suitable position near the bow thruster but just couldn't run the cable that far. I have considered building and installing a second single-channel unit and putting the transducer near the bow thruster.

There is 12V available there as the bow thruster is live even when the battery switches are off. I am well aware of your warning regarding the high voltages that will appear on the bow thruster supply when in use.

I was wondering if the bow thruster 12V supply could be used in conjunction with some filtering/isolation and (perhaps) another smaller 12V battery to power another ultrasonic unit. (D. B., St Ives, NSW)

● You may find that your positioning of the transducers, both on the stern, is sufficient protection against algae growth on the bow.

We suggest you wait a bit longer, until the end of summer (when algae growth is more prevalent) and then have your boat checked to see if the system is working satisfactorily.

If you find that a bow transducer is required, it would be possible in theory to come up with a power filter that would allow the unit to be run from the thruster battery.

But we would recommend instead that you build a single-channel Anti-Fouling unit and power it from its own 12V battery, charged by a solar panel/charger.

September 2014 issues (siliconchip.com.au/Series/275).

We have not tried it, so we cannot say if it would offer a significantly improved audible result.

Assuming you want to maintain the two-way system you will have to bi-wire and bi-amp everything and add extra binding posts. It would be a good idea to place a 4.7µF capacitor in series with the tweeter to protect it, in case someone gets the wires the wrong way around and ends up destroying it with some heavy bass signal.

You will not need to change the cabinet, apart from adding the extra binding posts, and you may have to extend your wires if you had cut them too short. All this will involve extra cost, extra amplifiers and a lot of wires lying around the place, so we don't think it will be worth doing, especially since the Majestic is already very good.

We were aiming for low cost and simplicity in the Majestic design and the results are pretty good, as you can attest.

Whirring noise from the PreCHAMP

I am having trouble trying to interface a mono dynamic microphone (250Ω impedance) to the sound card of my computer. I have found an old Jaycar "Pre-Champ" kit, Cat KC5166 (now apparently discontinued), based on your article in the July 1994 issue. It amplifies just fine but there is a continuous whirring sound in the background (only when the mic cable is plugged in). I suspect it may be rapid motor boating.

I see that on page 102 of the December 2011 issue, you answered a question about CHAMP noise and seemed to say it was an inherent problem. You recommended the Jaycar Short Circuit Volume 3 Project 13. According to my Jaycar catalogue, Project 13 is a High Power Amplifier (actually 13.5W) so obviously that would be unsuitable for this role.

Project 12 is stereo pre-amp, which might be suitable if I can connect it as mono. Was Project 13 a misprint? How do I connect Project 12 as mono? What do you recommend for low noise mono signal from a dynamic mic of 250Ω to a sound card? (A. F., Salamander Bay, NSW)

● That answer was in response to someone who had noise from the CHAMP, not the PreCHAMP. So if Project 13 is a 13.5W power amplifier, that seems like a reasonable alternative.

The whirring sound you have could be the circuit amplifying EMI which is being picked up by the microphone lead. EMI can be pretty pervasive. It could be from a switchmode power supply some distance away that's radiating through your mains wiring.

We aren't aware of any inherent problem with the PreCHAMP or it having a tendency to motorboat. We suggest you try shielding the circuit in an earthed metal (ideally steel) box.

The normal approach to sending a microphone signal over anything more than a short distance is to fit a microphone preamp with balanced output near the microphone and then send the signal over a shielded, balanced cable and convert it back to unbalanced at the far end, to feed to your sound card. That should be much more effective at rejecting buzz, hum, EMI and other undesired signals.

If you don't want to take that approach, an op-amp based preamp like the PreCHAMPION design from January 2013 (siliconchip.com.au/Article/1301) may be less susceptible to EMI. But we suggest you investigate the shielding option first.

45-Second Voice Recorder won't record

We have built the 45-Second Voice Recorder Module published in the May 2005 issue (siliconchip.com.au/Article/3058).

Our problem is that when we press the record button, the red LED flashes once but it won't record anything. (M. A., Hamersley, WA)

● We can only guess from your brief description of the problem that you might not be holding down S1 during the recording. If you simply press and release S1, you will just get one flash from LED2 and nothing will be recorded. Refer to the text on page 30 of the May 2005 issue.

This states that for recording, switch S2 should be in the Record position (whereupon the Record mode LED2 should begin glowing) and then push-button S1 is held down during the actual recording (during which Run LED1 should flash). If some or all of this is not happening, you may have a component orientation error or perhaps a dry solder joint.

By the way, we published an enhanced version of this project in the December 2007 issue (siliconchip.com.au/Article/2448) which could record and play back multiple different sound samples.

Where to find CH340G USB/serial driver

I bought an Arduino clone board and an Arduino development board on trademe, in New Zealand.

The seller says to go to siliconchip.com.au/link/aaip to download the CH340G USB/serial driver, however, the readme file on this site is gobbledegook and I am worried about "bricking" my desktop.

Can you direct me to a site that has a safe download for this driver? I am using Windows 10. (R. K., New Zealand)

● Try one of these:

Manufacturer driver download: www.wch.cn/download/CH341SER_EXE.html

Translated datasheet (may or may not be accurate): siliconchip.com.au/link/aain

Alternative driver download site: www.5y.ru/ch340g.htm

And here is a step-by-step guide with links: siliconchip.com.au/link/aaim

Adjustable regulator design wanted

Has your magazine (or *Electronics Australia*) ever published a project using LM317 or LM338 adjustable linear regulators? I'm looking for a PCB to replace an LM723-based PSU that no longer works. (G. N., Tumby Bay, SA)

● We have published at least three projects using the LM317 regulator:

1) 4-Output Universal Voltage Regulator, May 2015: siliconchip.com.au/Article/8562
2) MiniReg 1.3-22V Adjustable Regulator, December 2011: siliconchip.com.au/Article/1238
3) High-Current Adjustable Voltage Regulator, May 2008: siliconchip.com.au/Article/1830

Issue starting Induction Motor Speed Controller

I have an Altronics 1.5kW Induction Motor Speed Controller Kit, Cat K6032, as described in your April and

Recycling parts for the Ultrasonic Anti-Fouling unit

I built the original version of the marine Ultrasonic Anti-fouling system (September & November 2010; siliconchip.com.au/Series/12) from the Jaycar kit (Cat KC5498).

I'm now planning to build the revised version (May & June 2017; siliconchip.com.au/Series/312) from the Jaycar kit (single transducer version; Cat KC5535), salvaging parts for the second transducer from my original unit.

The problem I will have is obtaining the parts for the neon activity indicator, specifically the 220kΩ 1.6kV resistor, the 1nF 2kV capacitor and the UF4007 fast diode.

Will these be made available as a package from the SILICON CHIP online shop, as for some other hard to get parts? I most likely will obtain the two CSD18534KCS Mosfets from the SILICON CHIP online shop as well, as they are higher powered and will be more robust that the RFP30N06LE devices in my original unit.

My boat is a Top Hat 25 foot (7.8m) long keel sail vessel with a cutaway forefoot and tucked under rudder, and approximately two tonnes of lead in the keel (https://en.wikipedia.org/wiki/Top_Hat_25).

Its sections are typically wineglass in shape and the only flat(ish) panels are the sides of the bilge sump, at the aft end of the keel, after the ballast and forward of the rudder; a bit less than a square metre in area each side. This is where I fitted the transducer, in the middle of the panel on one side.

There was a clear reduction in fouling growth but more so on the side with the transducer. I imagine that the two tonnes of lead has a damping effect on the passage of the ultrasound from one side of the hull to the other, which is why I intend to build the dual transducer unit and fit a transducer on each side of the bilge sump (which is always dry, by the way).

How can a hobbyist constructor ascertain that both the Mosfets for a channel are operating correctly and whether the transducer is properly coupled to the hull, without some kind of monitoring tool? I know one can use an AM radio to show activity but this would still be evident even if one Mosfet had failed.

I was wondering if SILICON CHIP might consider designing something, say, based on the receiver section of the Ultrasonic Water Level Meter, driving a bar-graph or just a DVM.

Possibly with some means of calibration, whereby the ultrasound detector could be held against the back of the Anti-fouling transducer and on various panels of the hull, to show the level of ultrasonic vibration.

It could be used when the units were initially installed, and afterwards, for example at every haul-out or whenever some doubt existed that the units were operating properly.

Would the Banggood DSO recently reviewed in your pages (April 2017; siliconchip.com.au/Article/10613) be adequate to show that the Mosfets are functioning correctly?

Even so, the problem of ascertaining adequate coupling to the hull would remain. Such a device might also be useful to constructors for checking out other ultrasound projects as well.

By the way, I have enjoyed your magazine since it was RTV&H. (D. J., via email)

● Apart from the Mosfets you mention, we do not sell parts for this project since Jaycar have the exclusive rights to sell it.

Jaycar do have the UF4007 diode (Jaycar Cat ZR-1038) and you can substitute a 220kΩ 1W resistor for the one rated at 1.6kV. Altronics have a 1nF 3kV capacitor (Altronics Cat R2889).

Your approach with fitting two transducers on your complex hull should lead to better results.

As far as knowing that both Mosfets are working, it is doubtful whether there would be much output at all from the transformer secondary if only one Mosfet was working and this would mean that the neon indicator would not work.

Your suggestion about using the ultrasonic water level meter to monitor whether the hull is being excited is intriguing but we doubt whether it would have sufficient sensitivity to work.

We have thought long and hard about some sort ultrasonic hull detector but have not come up with anything workable.

Interestingly, some divers and others who have been under boats with the Ultrasonic Anti-Fouling working have reported that they feel "pressure in the ears".

May 2012 issues (siliconchip.com.au/Series/25). I finished building the kit, however, it is not functioning correctly.

The LED illuminates as expected but once a load is connected, it goes into fault mode (red fault led illuminated) and no power is output.

I have disconnected the feedback optocoupler from the power module and now the unit appears to work fine with a load connected. Ramp rate, reversing and variable speed all function correctly.

Could this be a faulty power module? Or something else in the circuit causing the fault? (J. T., via email)

● It seems that your load may draw a very high initial current and it's tripping the protection circuitry. Motors which start up under load, such as pool pumps, are tricky to get up to speed since they draw so much current when operating at low speed under load.

In the past, the solution has generally been to try lots of different ramp rate settings until you find one that works. The ramp has to be slow but not too slow.

When you say you "disconnected the feedback optocoupler", it sounds like you're bypassing the over-current protection which is pretty dangerous. Then there's nothing to stop the IGBT bridge from blowing. If you have to modify the protection, it's safer to slightly reduce the current sense resistor value so you still have at least some protection.

The standard current sense resistor is 15mΩ. You could try 10mΩ instead, increasing the current limit by 33%. The easiest way to do this is to solder a 30mΩ shunt on top of the 15mΩ shunt. However, we still don't recommend doing this as it's possible the module could be damaged before the over-current protection trips. SC

SILICON CHIP ONLINESHOP

.com.au/shop

Looking for a specialised component to build that latest and greatest *SILICON CHIP* project? Maybe it's the PCB you're after? Or a pre-programmed micro? Or some other hard-to-get "bit"? The chances are they are available direct from the *SILICON CHIP* ONLINESHOP.

As a service to readers, *SILICON CHIP* has established the ONLINESHOP. No, we're not going into opposition with your normal suppliers – this is a direct response to requests from readers who have found difficulty in obtaining specialised parts such as PCBs & micros.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, regardless of how many boards or micros you order! (Australia only; overseas clients – email us for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!

HERE'S HOW TO ORDER:

VISA MasterCard PayPal

All prices are in AUSTRALIAN DOLLARS ($AU)

- ✔ **Via the INTERNET** (24 hours, 7 days): Log on to our secure website – siliconchip.com.au, click on "SHOP" and follow the links
- ✔ **Via EMAIL** (24 hours, 7 days): email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details
- ✔ **Via MAIL** (24 hours, 7 days): PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details
- ✔ **Via PHONE** (9am-5pm EADST, Mon-Fri): Call (02) 9939 3295 (INT 612 9939 3295) – have your order ready, including contact and credit card details!

YES! You can also order or renew your SILICON CHIP subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *SILICON CHIP ONLINESHOP* stocks microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12), Do Not Disturb (May13)	**PIC16F877A-I/P** 6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10), Sentinel (Feb-May12)
	IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13)	**PIC16F2550-I/SP** Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
	PC Brides "2 chips – $15 pair" (Aug13), Driveway Monitor Receiver (July15)	**PIC18F4550-I/P** GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
	Hotel Safe Alarm (Jun16), 50A Battery Charger Controller (Nov16)	**PIC32MX795F512H-80I/PT** Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12)
	Kelvin the Cricket (Oct17)	Touchscreen Audio Recorder (Jun/Jul 14)
PIC12F675-I/P	Courtesy LED Light Delay for Cars (Oct14), Fan Speed Controller (Jan18)	**PIC32MX170F256B-50I/SP** Micromite Mk2 (Jan15) – *also includes* ***FREE*** *47µF tantalum capacitor*
PIC16F1455-I/P	Microbridge (May17)	Micromite LCD BackPack [either version] (Feb16), GPS Boat Computer (Apr16)
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)	Micromite Super Clock (Jul15), Touchscreen Voltage/Current Ref (Oct-Dec16)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13),	Micromite LCD BackPack V2 (May17), Deluxe eFuse (Aug17)
	Auto Headlight Controller (Oct13), 10A 230V Motor Speed Controller (Feb14)	Micromite DDS for IF Alignment (Sept17)
	Automotive Sensor Modifier (Dec16)	**PIC32MX170F256B-I/SP** Low Frequency Distortion Analyser (Jul15)
		PIC32MX170F256D-50I/PT 44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11)	**PIC32MX250F128B-I/SP** GPS Tracker (Nov13), Micromite ASCII Video Terminal (Jul14)
	Quizzical (Oct11), Ultra LD Preamp (Nov11), 10-Channel Remote Control	**PIC32MX470F512H-I/PT** Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14)
	Receiver (Jan13), Revised 10-Channel Remote Control Receiver (Jul13)	Digital Effects Unit (Oct14)
	Nicad/NiMH Burp Charger (Mar14), Remote Mains Timer (Nov14)	**PIC32MX470F512H-120/PT** Micromite PLUS Explore 64 (Aug 16), Micromite Plus LCD BackPack (Nov16)
	Driveway Monitor Transmitter (July15), Fingerprint Scanner (Nov15)	**PIC32MX470F512L-120/PT** Micromite PLUS Explore 100 (Sep-Oct16)
	MPPT Lighting Charge Controller (Feb16), 50/60Hz Turntable Driver (May16)	**dsPIC33FJ128GP802-I/SP** Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller
	Cyclic Pump Timer (Sep16), 60V 40A DC Motor Speed Controller (Jan17)	(Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11)
	Pool Lap Counter (Mar17), Rapidbrake (Jul17)	Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13), GPS Analog Clock Driver (Feb17)	**dsPIC33FJ64MC802-E/P** Induction Motor Speed Controller (revised) (Aug13)
PIC16LF88-I/SO	LED Ladybird (Apr13)	**dsPIC33FJ128GP306-I/PT** CLASSIC DAC (Feb-May 13)
PIC16LF1709-I/SO	Battery Cell Balancer (Mar16)	**ATTiny861** Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, HARD-TO-GET BITS, ETC

P&P – $10 Per order#

NEW THIS MONTH:

WiFi ANTENNAS WITH U.FL/PX CONNECTORS *(FEB 18)*

- 5dBi **$12.50**
- 2dBi (omnidirectional) **$10.00**

ALTIMETER/WEATHER STATION *(DEC 17)*

Micromite 2.8-inch LCD BackPack kit programmed for the Altimeter project **$65.00**
GY-68 barometric pressure and temperature sensor module (with BMP180) **$5.00**
DHT22 temperature and humidity sensor module **$7.50**

PARTS FOR THE 6GHz+ TOUCHSCREEN FREQUENCY COUNTER *(OCT 17)*

Explore 100 kit (Cat SC3834; no LCD included) **$69.90**
one ERA-2SM+ & one ADCH-80A+ (Cat SC1167; two packs required) **$15.00/pack**

3-WAY ADJUSTABLE ACTIVE CROSSOVER *(SEPT 17)*

set of laser-cut black acrylic case pieces **$10.00**

DELUXE EFUSE PARTS *(AUG 17)*

IPP80P03P4L04 P-channel mosfets **$4.00 ea**
BUK7909-75AIE 75V 120A N-channel SenseFet **$7.50 ea**
LT1490ACN8 dual op amp **$7.50 ea**

ARDUINO LC METER *(JUN 17)*

1nF 1% MKP capacitor, 5mm lead spacing **$2.50**

MICROBRIDGE *(MAY 17)*

PCB plus all on-board parts including programmed microcontroller (SMD ceramic X 10uF) **$20.00**

MICROMITE LCD BACKPACK V2 – COMPLETE KIT *(MAY 17)*

includes PCB, programmed micro, touchscreen LCD, laser-cut UB3 lid, mounting hardware, SMD Resistors for PWM backlight control and all other on-board parts **$70.00**

EFUSE *(APR 17)*

two NIS5512 ICs plus one SUP53P06 **$22.50**

POOL LAP COUNTER *(MAR 17)*

two 70mm 7-segment high brightness blue displays plus logic-level Mosfet, laser-cut blue tinted lid, 152 x 90 x 3mm **$17.50**
$7.50

STATIONMASTER *(MAR 17)*

Hard to get parts: DRV8871 IC, SMD 1µF capacitor and 100kW potentiometer with detent **$12.50**

ULTRA LOW VOLTAGE LED FLASHER *(FEB 17)*

kit including PCB and all SMD parts, LDR and blue LED **$12.50**

SC200 AMPLIFIER MODULE *(JAN 17)*

hard-to-get parts: Q8-Q16, D2-D4, 150pF/250V capacitor and five SMD resistors **$35.00**

60V 40A DC MOTOR SPEED CONTROLLER *(JAN 17)*

hard-to-get parts: IC2, Q1, Q2 and D1 **$35.00**

VARIOUS MODULES

NRF24L01+PA/LNA transceiver with SNA connector and antenna (El Cheapo 12, JAN18) **$5.00**
WeMos D1 R2 board (Logging data to the 'net using Arduino, SEPT17) **$15.00**
Geeetech Arduino MP3 shield (Arduino Music Player/Recorder, VS1053, JUL17) **$20.00**
AD9833 DDS module (with gain control) (for Micromite DDS, APR17) **$25.00**
AD9833 DDS module (no gain control) (El Cheapo Modules, Part 8, APR17) **$15.00**
CP2102 USB-UART bridge **$5.00**
microSD card adapter (El Cheapo Modules, Part 3, JAN17) **$2.50**
DS3231 real-time clock with mounting spacers and screws (El Cheapo, Part 1, OCT16) **$5.00**

TOUCHSCREEN VOLTAGE/CURRENT REFERENCE *(DEC 16)*

MICROMITE LCD BACKPACK KIT (programmed to suit) PLUS UB1 Lid **$70.00**
LASER-CUT MATTE BLACK LID (to suit UB1 Jiffy Box) **$10.00**
SHORT FORM KIT with main PCB plus onboard parts (not including BackPack module, jiffy box, power supply or wires/cables) **$99.00**

MICROMITE PLUS EXPLORE 100 "COMPLETE KIT (no LCD panel)" *(SEP 16)* **$69.90**
(includes PCB, programmed micro and the hard-to-get bits including female headers, USB and microSD sockets, crystal, etc but does not include the LCD panel)

THESE ARE ONLY THE MOST RECENT MICROS AND SPECIALISED COMPONENTS. FOR THE FULL LIST, SEE www.siliconchip.com.au/shop

All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. # P&P prices are within Australia. 9'ooas? Please email for a quote

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB only – *not a full kit.* If you want a kit, contact the kit suppliers advertising in this issue. For more unusual projects where kits are not available, some have specialised components available – see the list opposite.

NOTE: Not all PCBs are shown here due to space limits but the SILICON CHIP ONLINESHOP has boards going back to 2001 and beyond. For a complete list of available PCBs, back issues, etc, go to *siliconchip.com.au/shop* Prices are PCBs only, NOT COMPLETE KITS!

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	15102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$30.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	15104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHz UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JUL 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$30.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp [Sept'11])	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01107131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS (for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])	DEC 2013	01111131-3	$35.00/set
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender MK2	JAN 2014	01112131	$15.00
LI'l Pulser Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$12.50
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	19105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141a/b	$15.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THERMEIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THERMEIN PHOTOVOLTAIC SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	-	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
BAD VIBES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7.50
DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50
VOLTAGE/RESISTANCE/CURRENT REFERENCE	AUG 2015	04108151	$2.50
LED PARTY STROBE MK2	AUG 2015	16101141	$7.50
ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	15108151	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$12.50
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$15.00
TURNTABLE STROBE	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE LIGHT SPEEDUP	JAN 2016	05102161	$15.00
SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB/MAR 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB/MAR 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB/MAR 2016	07102122	$7.50
BATTERY CELL BALANCER	MAR 2016	11111151	$5.00
DELTA THROTTLE TIMER	MAR 2016	05102161	$15.00
MICROWAVE LEAKAGE DETECTOR	APR 2016	04103161	$5.00
FRIDGE/FREEZER ALARM	APR 2016	03104161	$5.00
ARDUINO MULTIFUNCTION MEASUREMENT	APR 2016	04116011/2	$15.00
PRECISION 50/60Hz TURNTABLE DRIVER	MAY 2016	04104161	$15.00
RASPBERRY PI TEMP SENSOR EXPANSION	MAY 2016	24104161	$5.00
100DB STEREO AUDIO LEVEL/VU METER	JUN 2016	01104161	$15.00
HOTEL SAFE ALARM	JUN 2016	03106161	$5.00
UNIVERSAL TEMPERATURE ALARM	JULY 2016	03105161	$5.00
BROWNOUT PROTECTOR MK2	JULY 2016	10107161	$10.00
8-DIGIT FREQUENCY METER	AUG 2016	04105161	$10.00
APPLIANCE ENERGY METER	AUG 2016	04116061	$15.00
MICROMITE PLUS EXPLORE 64	AUG 2016	07108161	$5.00
CYCLIC PUMP/MAINS TIMER	SEPT 2016	10108161/2	$10.00/pair
MICROMITE PLUS EXPLORE 100 (4 layer)	SEPT 2016	07109161	$20.00
AUTOMOTIVE FAULT DETECTOR	SEPT 2016	05109161	$10.00
MOSQUITO LURE	OCT 2016	25110161	$5.00
MICROPOWER LED FLASHER	OCT 2016	16109161	$5.00
MINI MICROPOWER LED FLASHER	OCT 2016	16109162	$2.50
50A BATTERY CHARGER CONTROLLER	NOV 2016	11111161	$10.00
PASSIVE LINE TO PHONO INPUT CONVERTER	NOV 2016	01111161	$5.00
MICROMITE PLUS LCD BACKPACK	NOV 2016	07110161	$7.50
AUTOMOTIVE SENSOR MODIFIER	DEC 2016	05111161	$10.00
TOUCHSCREEN VOLTAGE/CURRENT REFERENCE	DEC 2016	04110161	$12.50
SC200 AMPLIFIER MODULE	JAN 2017	01108161	$10.00
60V 40A DC MOTOR SPEED CON. CONTROL BOARD	JAN 2017	11112161	$12.50
60V 40A DC MOTOR SPEED CON. MOSFET BOARD	JAN 2017	11112162	$12.50
GPS SYNCHRONISED ANALOG CLOCK	FEB 2017	04202171	$10.00
ULTRA LOW VOLTAGE LED FLASHER	FEB 2017	16110161	$2.50
POOL LAP COUNTER	MAR 2017	19102171	$15.00
STATION/MASTER TRAIN CONTROLLER	MAR 2017	09103171/2	$15.00/set
ERUSE	APR 2017	01102171	$2.50
SPRING REVERB	APR 2017	01104171	$12.50
6GHz+ 1000:1 PRESCALER	MAY 2017	04112162	$7.50
MICROBRIDGE	MAY 2017	24104171	$2.50
MICROMITE LCD BACKPACK V2	MAY 2017	07104171	$7.50
10-OCTAVE STEREO GRAPHIC EQUALISER PCB	JUN 2017	01105171	$12.50
10-OCTAVE STEREO GRAPHIC EQUALISER FRONT PANEL	JUN 2017	01105172	$15.00
10-OCTAVE STEREO GRAPHIC EQUALISER CASE PIECES	JUN 2017		$15.00
RAPIDBRAKE	JUL 2017	05105171	$10.00
DELUXE ERUSE	AUG 2017	18106171	$15.00
DELUXE ERUSE UB1 LID	AUG 2017	SC4316	$5.00
MAINS SUPPLY FOR BATTERY VALVES (INC. PANELS)	AUG 2017	18108171-4	$25.00
3-WAY ADJUSTABLE ACTIVE CROSSOVER	SEPT 2017	01108171	$20.00
3-WAY ADJUSTABLE ACTIVE CROSSOVER PANELS	SEPT 2017	01108172/3	$20.00/pair
6GHz+ TOUCHSCREEN FREQUENCY COUNTER	OCT 2017	04110171	$10.00
KELVIN THE CHICKET	OCT 2017	08109171	$10.00
6GHz+ FREQUENCY COUNTER CASE PIECES (SET)	DEC 2017		$15.00
SUPER-7 SUPERHET AM RADIO PCB	DEC 2017	06111171	$25.00
SUPER-7 SUPERHET AM RADIO CASE PIECES	DEC 2017		$20.00
THEREMIN	JAN 2018	23112171	$12.50
PROPORTIONAL FAN SPEED CONTROLLER	JAN 2018	05111171	$2.50

NEW THIS MONTH:

WATER TANK LEVEL METER (INCLUDING HEADERS)	FEB 2018	21110171	$7.50
10-LED BARAGRAPH	FEB 2018	04101181	$7.50
10-LED BARAGRAPH SIGNAL PROCESSING	FEB 2018	04101182	$5.00

OOPS!

Did You Forget Someone Special at Christmas Time? Here's the perfect (late!) Christmas Gift: A SILICON CHIP subscription!

It's the perfect way to say "oops – sorry!" . . . give the gift that keeps on giving – month after month after month! Or even give it to yourself!

SILICON CHIP is Australia's only monthly magazine focused on electronics and technology. Whether for a PhD in quantum mechanics, or the newest beginner just starting out, SILICON CHIP is the one magazine that they'll want to read from cover to cover, every month.

Print subscriptions actually cost less than buying over the counter! Prices start at just $57 for six months, $105 for 12 months or $202 for 24 months. And yes, we have binders available (Australia only) to keep those magazines safe!

Taking out a gift subscription for someone special has never been easier. Simply go to our website, click on the <SUBSCRIBE> tab and select <GIFT SUBSCRIPTIONS>. We'll even send a special message from you to the recipient . . . AND we'll send you a reminder when the subscription is about to fall due. What could be easier?

Or email us – silchip@siliconchip.com.au – 24 hours a day, 7 days a week. Don't forget to let us know their (or your!) details.

- ✔ Remember, it's cheaper to subscribe anyway . . . do the maths and see the saving!
- ✔ Remember, we pick up the postage charge – so you $ave even more!
- ✔ Remember, they don't have to remember! It's there every month in their letter box!
- ✔ Remember, your newsagent might sell out – and they'll miss out!
- ✔ Remember, there's also an on-line version you can subscribe to if you're travelling.
- ✔ Remember, subscribers qualify for a 10% discount on any item from the online shop* *excluding subscriptions

We're waiting to welcome them – or you – into the SILICON CHIP subscriber family!

A GIFT SUBSCRIPTION MAKES LOTS OF SENSE AND SAVES LOTS OF CENTS!

www.siliconchip.com.au

MARKET CENTRE

Cash in your surplus gear. Advertise it here in SILICON CHIP

FOR SALE

tronixlabs.com.au – Australia's best value for supported hobbyist electronics from Adafruit, SparkFun, Arduino, Freetronics, Raspberry Pi – along with kits, components and much more - with same-day shipping.

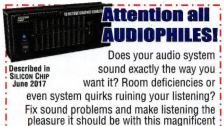
PCBs MADE, ONE OR MANY. Any format, hobbyists welcome. Sesame Electronics Phone 0434 781 191.
nev-sesame@outlook.com
www.sesame.com.au

LEDs, BRAND NAME and generic LEDs. Heatsinks, fans, LED drivers, power supplies, LED ribbon, kits, components, hardware, EL wire.
www.ledsales.com.au

PCB MANUFACTURE: single to multi-layer. Bare board tested. One-offs to any quantity. 48 hour service. Artwork design. Excellent prices.
Check out our specials:
www.ldelectronics.com.au

WANTED

WANTED: EARLY HIFIs, AMPLIFIERS, Speakers, Turntables, Valves, Books, Quad, Leak, Pye, Lowther, Ortofon, SME, Western Electric, Altec, Marantz, McIntosh, Tannoy, Goodmans, Wharfedale, radio and wireless.
Collector/Hobbyist will pay cash.
Phone (07) 5471 1062.
johnmurt@highprofile.com.au



Attention all AUDIOPHILES!

Described in SILICON CHIP June 2017

Does your audio system sound exactly the way you want it? Room deficiencies or even system quirks ruining your listening? Fix sound problems and make listening the pleasure it should be with this magnificent

10-Octave Graphic Equaliser

– the very latest in a long line of high-spec audio gear from the **SILICON CHIP** laboratory.

View online at siliconchip.com.au/Article/10674
PCB & hard-to-get bits available from SILICON CHIP online shop

ORDER NOW AT
www.siliconchip.com.au/shop

KIT ASSEMBLY & REPAIR

DAVE THOMPSON (the Serviceman from SILICON CHIP) is available to help you with kit assembly, project troubleshooting, general electronics and custom design work. No job too small. Based in Christchurch, NZ but service available Australia/NZ wide.
Email **dave@davethompson.co.nz**

VINTAGE RADIO REPAIRS: electrical mechanical fitter with 36 years experience and extensive knowledge of valve and transistor radios. Professional and reliable repairs. All workmanship guaranteed.
$17 inspection fee plus charges for parts and labour as required. Labour fees $38 p/h. Pensioner discounts available on application.
Contact Alan on 0425 122 415 or email **bigalradioshack@gmail.com**

KEITH RIPPON KIT ASSEMBLY & REPAIR:
* Australia & New Zealand;
* Small production runs.

Phone Keith 0409 662 794.
keith.rippon@gmail.com

ADVERTISING IN MARKET CENTRE

Classified Ad Rates: $32.00 for up to 20 words (punctuation not charged) plus $1.20 for each additional word. Display ads in Market Centre (minimum 2cm deep, maximum 10cm deep): $82.50 per column centimetre per insertion. All prices include GST. Closing date: 5 weeks prior to month of sale. To book, email the text to **silicon@siliconchip.com.au** and include your name, address & credit card details, or phone Glyn (02) 9939 3295 or 0431 792 293.

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

Advertisers are warned that they are responsible for the content of all advertisements and that they must conform to the Competition & Consumer Act 2010 or as subsequently amended and to any governmental regulations which are applicable.

Coming up in Silicon Chip

Vintage TV RF Modulator

This circuit allows you to drive a vintage TV from a composite video source such as a DVD player. It is optimised to provide the best video quality for older TVs and incorporates vertical blanking removal circuitry to avoid buzzing noises from the TV's sound decoder. It uses six ICs and some discrete and passive components.

El Cheapo Modules - ESP8266 WiFi modules and boards

We've used ESP8266/ESP32 modules and boards in a few of our projects now. They are ideal for any microcontroller-based project which requires internet access. This article will provide more detail on what's available.

Triac-based Motor Speed Controller

We've published many mains motor speed controllers in the past, including several based on Triacs but this is our best yet. It avoids many of the pitfalls of Triac-based controllers and gives very smooth speed control, including operation at very low speeds. It's relatively simple and quite easy to build, too.

Earthquake Early Warning

It's possible to get early warning before a devastating earthquake by sensing the "P waves" which travel through the Earth faster than the damaging "S waves". It could give you 30 seconds or even a minute to get to a safe place. This article describes the electronics required to form an early warning system.

AM Transmitter for Vintage Radios

AM radio stations may start to disappear in a few years. If that happens, you will need a low-power AM radio transmitter such as this one to continue enjoying vintage radios. It's also handy for playing MP3s or CDs through an AM radio.

Note: these features are planned or are in preparation and should appear within the next few issues of Silicon Chip.

The March 2018 issue is due on sale in newsagents by Thursday, February 22nd. Expect postal delivery of subscription copies in Australia between February 22nd and March 9th.

Advertising Index

Altronics 74-77
Dave Thompson 103
Digi-Key Electronics 3
Emona Instruments ..... IBC
Hare & Forbes ..... OBC
High Profile Communications 103
Icom Pty Ltd 13
Jaycar IFC,49-56
Keith Rippon Kit Assembly 103
LD Electronics 103
LEACH Co Ltd 9
LEDsales 103
Microchip Technology 7
Ocean Controls 11
Rohde & Schwarz 5
Sesame Electronics 103
SC Online Shop 100-101
SC Radio, TV & Hobbies DVD 96
Silicon Chip Binders 10
Silicon Chip Subscriptions 102
The Loudspeaker Kit.com 6
Tronixlabs 103
Vintage Radio Repairs 103
Wagner Electronics 35

Notes & Errata

UV Light Box & Timer, November 2007: the errata in the August 2008 issue regarding this project is wrong. There is no 47kΩ resistor (it's 4.7kΩ) and it should not be installed. The three 10kΩ pull-up resistors mentioned in the March 2012 errata should be fitted instead. These can be soldered between the following pairs of IC pins on the underside of the board: pins 3 & 4, pins 12 & 14, pins 13 & 14.

Micromite BackPack Touchscreen DDS Signal Generator, April 2017: add three chassis-mount RCA sockets to the parts list.

Deluxe Touchscreen eFuse, July, August & October 2017: in the circuit diagram (Fig.3) on pages 44 and 45 of the July 2017 issue, the resistors connecting to pins 24 and 26 of IC1 are shown incorrectly. The 390kΩ/30kΩ and 27kΩ/3kΩ pairs should be swapped. The same is true of the overlay diagram on page 63 of the August 2017 issue. The resistors to swap are above REG3 (390kΩ) and just above Q4 (30kΩ), and to the right of REG1 (27kΩ) and above and to the left of REG3 (30kΩ). Also, the PCB overlay incorrectly shows ZD8 (just above Q6) as ZD4. The PCBs supplied are correctly labelled and the online versions of these issues have been corrected.

Kelvin the Cricket, October 2017: there is a bug in the software which prevents modes 13-16 from working properly. Revised firmware (0810917B) is available for download from the Silicon Chip website and chips supplied from now on will be programmed with this new version.

"Rigol Offer Australia's Best Value Test Instruments"

Oscilloscopes

RIGOL DS-1000E Series

- 50MHz & 100MHz, 2 Ch
- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

FROM $469 ex GST

NEW RIGOL DS-1000Z Series

- 50MHz, 70MHz & 100MHz, 4 Ch
- 1GS/s Real Time Sampling
- 12Mpts Standard Memory Depth

FROM $579 ex GST

RIGOL DS-2000A Series

- 70MHz, 100MHz & 200MHz, 2 Ch
- 2GS/s Real Time Sampling
- 14Mpts Standard Memory Depth

FROM $1,199 ex GST

Function/Arbitrary Function Generators

RIGOL DG-1022

- 20MHz Maximum Output Frequency
- 2 Output Channels
- USB Device & USB Host

ONLY $539 ex GST

NEW RIGOL DG-1000Z Series

- 30MHz & 60MHz
- 2 Output Channels
- 160 In-Built Waveforms

FROM $971 ex GST

RIGOL DG-4000 Series

- 60MHz, 100MHz & 160MHz
- 2 Output Channels
- Large 7 inch Display

FROM $1,313 ex GST

Spectrum Analysers

RIGOL DSA-800 Series

- 9kHz to 1.5GHz, 3.2GHz & 7.5GHz
- RBW settable down to 10 Hz
- Optional Tracking Generator

FROM $1,869 ex GST

Power Supply

RIGOL DP-832

- Triple Output 30V/3A & 5V/3A
- Large 3.5 inch TFT Display
- USB Device, USB Host, LAN & RS232

ONLY $649 ex GST

Multimeter

RIGOL DM-3058E

- 5 1/2 Digit
- 9 Functions
- USB & RS232

ONLY $673 ex GST

Buy on-line at www.emona.com.au/rigol

Sydney
Tel 02 9519 3933
Fax 02 9550 1378

Melbourne
Tel 03 9889 0427
Fax 03 9889 0715

Brisbane
Tel 07 3392 7170
Fax 07 3848 9046

Adelaide
Tel 08 8363 5733
Fax 08 83635799

Perth
Tel 08 9361 4200
Fax 08 9361 4300

EMONA

email testinst@emona.com.au

web www.emona.com.au

HARE&FORBES MACHINERYHOUSE

"Setting the standard for Quality & Value"

A family owned Australian business Established 1930

THE INDUSTRY'S CHOICE!

CNC Machinery | Metal Working | Sheet Metal Fabrication | Wood Working | Workshop & Automotive | Lifting Handling | Cutting Tools | Machine Tool Accessories | Measuring Equipment

CB6-5S Carbide Burr Double Cut Set

- 5 piece set
- Industrial quality double cut burrs
- SD-3, SE-3, SA-3, SC-3, SF-5
- Ø1/4" x 1-1/2" shank

$82.50 (B900)

Deburring Tool

- Ergonomically designed
- Telescopic shaft
- Blades can be stored from the back side
- Includes 10 x HSS blades

$29.70 (D060)

PTD54 Pipe/Tube Deburring Tool

- Double ended internal/external Ø10 - Ø54mm range
- Aluminium knurled body
- Hardened cutting edge
- Suitable for steel, stainless & copper

$74.80 (D068)

EF-5S Engineers File Set

- 200mm hardened and tempered files
- Second cut: Flat, 1/2 Round, Round, Square, Triangular
- Includes carry case

$42.35 (F100)

RNB40 Nut & Blind Riveter Set

- Blind aluminium rivets (20 of each size): Ø3.2, Ø4.0, Ø4.8, Ø6.4mm
- Aluminium rivet nut inserts (10 of each size): M5, M6, M8, M10
- Mandrel spanner & blow mould case
- 130 piece set

$132 (N001)

Metric Hex Key Set

- 2, 2.5, 3, 4, 5, 6, 8, 10mm
- Chrome vanadium steel
- Adjustable 3 detent positions on T-bar handle
- Free spinning rotating handle

$82.50 (H820)

Imperial Hex Key Set

- 5/64, 3/32, 1/8, 5/32, 3/16, 1/4, 5/16, 3/18"
- Chrome vanadium steel
- Adjustable 3 detent positions on T-bar handle
- Free spinning rotating handle

$82.50 (H821)

Torx Key Set

- T10, T15, T20, T25, T27, T30, T40, T45, T50
- Chrome vanadium steel
- Adjustable 3 detent positions on T-bar handle
- Free spinning rotating handle

$82.50 (H822)

Model 480 Professional Engraver

- Ergonomic design
- 100 strokes per minute
- Adjustable penetration depth
- Includes 4 engraving points

$84.70 (R990)

SFH-M40 Soft Face Hammer

- Ø45mm soft faces
- 1 x Copper insert
- 1 x Steel insert
- 1 x Aluminium insert
- 1 x Polyurethane (Pu) insert
- 1 x Nylonn insert
- 300mm hickory handle

$78.65 (H875)

EP-180 Straight Edge/Seaming Plier

- 180° flat edge
- 57mm wide jaw
- 60mm depth
- 275mm overall length

$49.50 (S203)

EP-90 90° Edge/Seaming Plier

- Plastic coated hand grips
- 57mm wide jaw
- 55mm depth
- 260mm overall length

$49.50 (S205)

35-2015 Universal Dial Bevel Protractor

- 0-360°
- Round dial face
- Stainless steel rules & chrome plated body

$132 (Q2015)

70-645 Precision Steel Square

- BSS:939 Grade "B"
- 100mm blade length
- 75 x 11mm base
- Hardened spring steel blade
- True right angle inside and outside

$42.35 (Q645)

SE500 Straight Edge with Bevel

- 500 x 40 x 8mm
- Straight edge & 30° bevelled edge
- Manufactured to DIN 874 / 2
- Made in Germany

$99 (M706)

505-671 Dial Caliper

- 150mm
- 0.02mm graduations
- Made in Japan

$143 (M100)

35-2005 Combination Set

- 300mm / 12"
- Metric & imperial rule
- High accuracy 2 piece set
- Cast iron ground finished

$132 (Q2005)

XH-2P - 2-Axis Digital Readout Package Deal

- Multi function counter suits lathes & mills
- 2 x Scales from 170 – 1020mm
- 1 x Bracket kit

SINO

$440 (KS200)

XH-3P - 3-Axis Digital Readout Package Deal

- Multi function counter suits lathes & mills
- 3 x Scales from 170 – 1020mm
- 1 x Bracket kit

SINO

$550 (KS202)

UNIQUE PROMO CODE

SCFEB8

ONLINE OR INSTORE!

VIEW AND PURCHASE THESE ITEMS ONLINE AT www.machineryhouse.com.au/SCFEB8

SYDNEY	BRISBANE	MELBOURNE	PERTH
(02) 9890 9111	(07) 3274 4222	(03) 9212 4422	(08) 9373 9999
1/2 Windsor Rd, Northmead	625 Boundary Rd, Coopers Plains	1 Fowler Rd, Dandenong	11 Valentine St, Kewdale

Specifications & Prices are subject to change without notification. All prices include GST and valid until 28-02-18